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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CVI.—No. 2754.] *LONDON: FRIDAY, OCTOBER 11, 1918.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...9d. BY INLAND POST ... 10½d.

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SYPHON-JET STEAM TRAPS, REDUCING VALVES.
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6877
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See Full Page Advt., page 70, Sept. 20.

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See Advertisement page 73, Sept. 27. 3402

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See Full Page Advertisement Sept. 20.

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Pott, Cassels & Williamson,
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See half-page Advertisement page 82, Oct. 4.

The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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The Institution of Gas Engineers.

Samuel Glover, Esq., M.Inst.C.E., President.

A SPECIAL GENERAL MEETING of the Institution will be held at the Institution of Civil Engineers, on Thursday and Friday, 17th and 18th October, at Ten a.m. each day, for the consideration of the following:—

(1) Representation of the Institution of Gas Engineers on the proposed reconstructed National Gas Council.

(2) Preliminary Report of the Gas Investigation Committee, to be introduced by Lieut.-Col. Arthur Smithells, O.M.G., Chairman of the Research Sub Committee, and Professor John W. Cobb, B.Sc., Livesey Professor.

(3) Life of Gas Meters Research Committee's Report: "Unaccounted for Gas," by B. E. Parkinson, M.I.Mech.E.

"The Corrosion of Dry Meters," by J. G. Tapley, Chief Analyst to the Gas Light and Coke Co.

(4) Report of the Refractory Materials Research Committee: "The Corrosive Action of Fine Dust on Fire Bricks," by Walter Emery and Dr. A. Scott, of Stoke-on-Trent. Dr. J. W. Mellor, Reporter.

Forms of proposal for Membership and Studentship from those desiring to join the Institution should be received here by the 16th October.

Walter T. Dunn, Secretary.

39, Victoria Street, Westminster, S.W. M 971

Engineering Special Classes.

Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—Pennington's, University Tutors, 264, Oxford Rd., Manchester.

TENDERS.

GREAT NORTHERN RAILWAY COMPANY (IRELAND).

CONTRACTS FOR GENERAL STORES.

The Directors of the Great Northern Railway Company (Ireland) are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Six or Twelve Months, from the 1st January, 1919.

	No. of Form.		No. of Form.
Axles and Tyres (Steel)	1	Iron Plates, Bars, Angles, Tees, and Forgings (best Staffordshire and Yorkshire)	27
Baskets, Brooms Brushes, Mats, and Sponges	2	Lamps (Oil) and Brass Carriage Fittings, Oiler Pads, and Enamelled Iron Plates	28
Bolts and Nuts, Studs, Pins, Rivets, and Washers	3	Lead (ground in oil and dry), Sheet, &c.	29
Boxes, Farm and Market Produce	4	Leather and Leather Goods, and Balata Belting	30
Brass and Copper Sheets Plates, Tubes & Wire, Block Tin, Zinc, Spelter, and Patent Metal	5	Nails	31
Buckets, Oil Cans, Zinc Sheets, Galvanized Iron Sheets, Emery, etc.	6	Oil (Creosote)	32
Buffers & Axle Guards for Carriages and Wagons, Wagon Hinges, Barrow Frames, &c.	7	Oilskin Suits	32A
Canvas	8	Oils (Burning, Lubricating, &c.)	33
Castings (Ordinary Iron, Firebars, Forgings, Crucibles, Cylinders, & Buffer Stops	9	Plates (Steel Boiler), Steel Forgings, Fish Plate Liners, Cast Steel Engine and Tender Wheel Centres, Roof Bars, and Mild Steel Plates, Bars, Angles, Tees, and Channels	34
Cement, Plaster of Paris, Slates, Glazed Ware Pipes, Fire Bricks, Tiles, &c.	10	Rope, Twine, Flax, and Hemp Gaskin	35
Chain	11	Screws (Iron & Brass), Split Pins, &c.	36
Colours, &c. (ground in oil and Dry) and Hall's Distemper, Wall Paper, &c.	12	Signalling Materials	37
Drysalteries	13	Springs for Engines, Carriages, Wagons, &c.	38
Electrical Fittings Lamps, &c.	14	Tin Plates	39
Electric Cable and Wire	15	Timber, White American Oak Scantlings, St. John's Spruce Plank, Logs, Planks, Boards, Mouldings, Sheetings, &c.	40
Electric Light Carbons	16	Transfers (Carriage, &c.)	41
Explosives, Fog Signals and Carbide of Calcium for Acetylene Gas Lighting	17	Tools (Edge), Saws, Files, Tool Steel, Carriage Keys, Hammers, Shovels, Spades, &c.	42
Fastenings, Permanent Way	18	Tubes and Fittings (Iron), Wire, Wire Work, Panel Pins, Staples, and Point Rodding	43
Fittings, (Brass for Gas and Water, Gas Burners, Gunmetal Steam Unions Rain Water Pipes, &c.	19	Tubes (Steel—Galvanized), Cold Drawn Weldless for Boilers	44
Gas Mantles	21	Upholstery for Carriages, Curled Hair, Blinds, Rugs, Linoleums, Tape, and Soft Goods	45
Gauges, Steam and Vacuum Brake	22	Varnishes, Enamel, Black Lacquer, and Sheet Dressing Composition	46
Glass	23	Waste (Cotton), Wick, Sponge Cloths, &c.	47
Hammer, &c., Handles, Barrows, Oak Keys, Loading Boards and Scotches	24		
Hinges (Wrought Iron and Brass), Locks and Keys, Hardware (Iron and Brass), Closet Basins and Seats, &c.	25		
Indiarubber Goods, Loco. Packing, Asbestos, &c.	26		

Forms of Tender can be obtained from the Secretary on payment of One Shilling for each Form. *Please do not send stamps.*

Tenders must be for the supply of Goods in accordance with the Company's patterns; these patterns may be seen at the General Stores Depot, Dundalk (they cannot be sent away for inspection), between the hours of 10 a.m. and 4 p.m. on each week day except Saturdays.

Tenders, made out on the Company's Forms, should be delivered, under sealed cover endorsed "Tender for Stores," to the undersigned, not later than 10 a.m. on the 7th November, 1918.

The Directors do not bind themselves to accept the lowest or any Tender.

T. Morrison, Secretary.

Secretary's Office, Amiens Street, Terminus, Dublin, 10th October, 1918. O 71

EDINBURGH CORPORATION.

The Corporation of Edinburgh invite

Offers for the Purchase of a

Four-Wheeled SADDLE-TANK LOCO., by Baird & Sons, Hamilton. Cylinders 12 in. by 18 in., wheels 3 ft.

The Engine is at present in disrepair, and can be seen at Camps Siding, Mid Calder. Further particulars may be had from the INSPECTOR OF CLEANSING, City Chambers, Edinburgh. Offerers must be prepared to take the engine in its present condition, and such offers marked "Tender for Loco," should be lodged with the Subscriber not later than 15th October, 1918.

A. Gibbson, S.S.C., Town Clerk.

City Chambers, Edinburgh, 3rd October, 1918. O 21

APPOINTMENTS OPEN.

COVENTRY EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL INSTITUTE.

The Committee invite

Applications for the Post of

HEAD of the ENGINEERING DEPARTMENT at the Municipal Technical Institute. The candidate appointed will be required to take up his duties as early as possible. The commencing salary will be £400 per annum.

Further particulars and form of application, which must be returned not later than Monday, 28th October, 1918, will be forwarded on receipt of a stamped addressed foolscap envelope.

Frndk. Horner, Secretary.

Education Department Council House, Coventry, 1st October, 1916. M 970

ROYAL AIRCRAFT ESTABLISHMENT.

An Assistant Master

REQUIRED immediately for the above Works Trade Lads School. The Syllabus at present includes English, Mathematics, Engineering, Science subjects, and Drawing.

Preference will be given to candidates having Practical Engineering and Teaching experience.

Applications and requests for further information should be addressed to:—

The Superintendent, Royal Aircraft Establishment, South Farnborough, Hants. M 965

KENT EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, MAIDSTONE.

Required immediately, chiefly

for day work in the Junior Technical School, an ASSISTANT MASTER or MISTRESS qualified in science and mathematics. Initial salary, woman, £300; man, with engineering science qualifications, £350.

Apply immediately to PRINCIPAL, Technical Institute, Maidstone.

E. Salter Davies, Director of Education.

September, 1918. O 45

Teachers.—Wanted, Visiting

TEACHERS of (1) Electrical Engineering, on Tuesdays and Thursdays from 7–9 p.m.; (2) of Applied Mechanics and Heat Engines, on Wednesdays, from 7–9 p.m.; (3) of Mathematics, on Tuesdays, from 7–9 p.m.; and (4) of Machine Drawing, on Thursdays, 7–9 p.m., at the School of Engineering and Navigation, High St., Poplar, E. Salary, 10s. 6d. an attendance.

Apply to the EDUCATION OFFICER (T. 1), Education Offices, Victoria Embankment, W.C. 2 (stamped, addressed foolscap envelope necessary). A form, giving particulars, will then be sent. Form must be returned by 11 a.m. on 23rd October, 1918. Canvassing disqualifies. O 21

Manager Required for Small

Steel Foundry in Hong Kong, which is being enlarged and reorganised. Applicants must be able to advise and superintend the laying out of modern steel foundries, including crucible, electric and open hearth furnaces. Applications from suitable discharged men would be considered. — Apply, stating age, experience, qualifications, salary required, references, &c., to BOX 760, care of Leathwait & Simmons, 5, Birchin Lane, E.C. 3. M 719

GOVERNMENT OF THE UNION OF SOUTH AFRICA.

DEPARTMENT OF RAILWAYS & HARBOURS.

ESTABLISHMENT OF GRAIN ELEVATORS.

The Government of the Union of South Africa purposes to adopt the Elevator System in connection with the handling of Maize at two or three Union Ports and at Inland centres generally.

Applications are Invited

from Consulting Engineers, possessing special qualifications and experience. The Consulting Engineer will be required to visit South Africa at the earliest possible date, and to advise the Government on this subject generally, including questions of the design, capacity, construction, and method of operation and location of the elevators. He will be required to prepare, in the Union of South Africa, a full report and detailed plans and specifications. Draughtsmen and other necessary assistance will be provided by the Government of the Union of South Africa.

A comprehensive report on Union trade conditions and requirements is available in the Union.

Applications, with testimonials, giving full details of qualifications, experience and terms of remuneration sought (on the basis of a fee plus monthly expenses), should be received by the HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA, 32, Victoria Street, London, S.W. 1, if possible before the end of November, but in special circumstances later applications from overseas may be considered. M 921

Secretary Wanted, by a Firm

of Engineers and Founders (Limited Co.) in the Midlands. Must be able to supervise finance, cost and secretarial departments. Chartered accountant preferred. State experience, age and salary required.—Address, M 966, Offices of Engineering.

Assistant Secretary and

ACCOUNTANT WANTED by large firm of Engineers in Eastern Counties, fully qualified Accountant (free of military service). Must have practical experience of Secretarial work, including Cost Accounts. Good organiser. Chartered Accountant preferred. State experience, age, and salary required.—Address, G.P.O. BOX 42, Sheffield. O 73

A Cost Clerk (Male) Wanted,

for Government Controlled Establishment. Must be well used to Engineering Works Accountancy and an efficiently competent man. No one already employed on Government work will be engaged.—Applicants should give details of their experience and state age and salary required, and apply to the nearest EMPLOYMENT EXCHANGE, mentioning this Journal and O 6.

Wanted, for Large Sheffield

Steel Works, Technical ASSISTANT, in Department manufacturing light tools of a repetition character. It is essential that candidates should have had an Engineering training. The position would be a progressive one to a man possessing tact, energy and initiative. No person already employed on Government work will be engaged.—Apply, giving full particulars of experience, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5991. M 903

Wanted Immediately, for

large Seaplane Factory on the South Coast, thoroughly practical MAN to take up the position of Chief Estimator and Rate Fixer. No applications will be considered except those who have had considerable experience on this class of work. First-class references must be submitted. Permanency to suitable man. No one already engaged on Government work will be employed.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and O 35.

Works Manager, with Special

knowledge of mass production of telephones and kindred electrical apparatus, including magnetos for spark ignition. Must be first-class all-round organiser, experienced mechanic, good man of methods and used to the sole control of large works (2000 employees). Only those having held similar positions need apply.—Write only, in first instance, stating fully, experience, age and salary required. Liberal terms to man of first-class ability.—Sterling Telephone & Electric Co., Ltd., 210, Tottenham Court Rd., W. 1. M 976

Assistant (Technical) for

Patent Agent's office in London. Must be of good education with a knowledge of engineering both electrical and mechanical. Acquaintance with the French and German languages would be an advantage. Sedentary employment suitable for rejected, discharged or disabled Service man. Good salary.—Write, BOX 945, Sells, Ltd., 168, Fleet Street, E.C. 4. O 18

Research Chemist Wanted,

knowledge of organic chemistry and experience in general metallurgical analysis essential). No one at present engaged on Government work need apply—Apply, stating age, experience, and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. A 6131. M 997

Wanted, Material and Brick-

work ESTIMATOR for Controlled Establishment in the Midlands, manufacturing furnaces and heat treatment plants. Permanent and progressive position.—Address, stating age, salary required, and full particulars, O 10, Offices of Engineering.

CORPORATION OF CALCUTTA.

Applications are Invited for

the post of CHIEF ENGINEER to the Corporation of Calcutta. The salary of the appointment, inclusive of all allowances, is Rs. 2,000 rising to Rs. 2,500 per month payable as follows:—

1st and 2nd year	...	...	Rs. 2,000
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7th and 8th year	...	...	,, 2,300
9th year	...	...	,, 2,400

and Rs. 2,500 during the 10th and last year of the appointment for approved service. The appointment will be for a period of 10 years renewable at the discretion of the Corporation. It is subject to the Provident Fund, leave and other service rules of the Corporation and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 6¼ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation and the fund accumulates at compound interest. The selected candidate will be required to devote his whole time to the duties of his office and will not be allowed to take up any outside work. He will be in superior charge of the Water Works, Drainage, Roads, Conservancy, Workshops and other engineering requirements of the city. He will be required to reside in Calcutta. He will be liable to removal during the term of his office for misconduct, or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment. The Corporation will pay his passage (1st class) from London to Calcutta. He will be required to take up his appointment about January, 1919, and to execute an agreement in accordance with the foregoing terms.

(b) Preference will be given to candidates who are Members or Associate Members of the Institution of Civil Engineers, or Graduates in Engineering of a University.

(c) Candidates are to state their age and experience.

(d) Applications will be received in England up to the 25th October, 1918, by S. W. Goode, Esq., I.C.S., care of Messrs. Henry S. King & Co., 65, Cornhill, London, from whom any other information concerning the conditions of service, &c., may be obtained, or in Calcutta up to the 10th December, 1918, by the Secretary to the Calcutta Corporation, Municipal Office.

(e) Applicants must guarantee that they will be permitted to leave the United Kingdom to take up the appointment in India, in the event of their being selected for the post, and must state the reasons which enable them to give such a guarantee.

S. C. Chatterjee, Secretary to the Corporation. O 4

A Competent Inspector Re-

QUIRED, in Woolwich district, to take charge of Screw Gauge Inspection to N.P.L. limits. Salary £5 to £6 p.w., according to qualifications. Man with some technical training preferred. No one outside 10 miles radius or already on Government work need apply.—Apply to Pitter's Ventilating & Engineering Co., Ltd., Woolwich. O 86

Wanted, Engineer to act as

Chief Assistant in Aero Engine Testing Shop in Midlands. Must have petrol engine experience and hold Engineering Degree or equivalent qualification. No person already employed on Government work will be engaged.—Apply, in first instance, stating salary required, etc., to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 6136. O 36

Engineer Wanted, with Ex-

perience of Chemical Plant, to undertake detailed design and general arrangements. One who could control Drawing Office and has good general experience. — State age, salary required, education and experience, to M 880, Offices of Engineering. No one engaged on Government work or resident more than 10 miles away will be employed. M 880

Engineer Wanted, with Good

theoretical training; one with experience in Chemical Plant preferred, or with knowledge of Chemistry. Must be a gentleman of good education and appearance. State age, salary required, training and experience. No one engaged on Government work or resident more than 10 miles away will be employed.—Address, M 681, Offices of Engineering.

Engineer Wanted, to take

charge of repairs and maintenance on a Chemical Works in London Applications will only be considered from men discharged H.M. Forces after active service.—Address, stating age, qualifications, experience, etc., M 933, Offices of Engineering.

Assistant Engineers,

Railway Maintenance, REQUIRED for the Government service in West Africa. Salary £300 a year upwards, with free passages and quarters, and liberal leave on full salary.

Candidates, *having actual training and experience*, should apply by letter, giving details of age, experience and position respecting military service, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1. O 39

Assistant Engineer Required,

by large firm of Internal Combustion Engine Manufacturers. Must have had a good technical and practical education. Preference given to one with experience in the design of high compression marine oil engines. No one on Government work need apply. State age, full details of experience, salary required and when at liberty to commence.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 6161. O 41

Technical Engineer Wanted,

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THE ELLIPTIC TRAJECTORY OVER THE EARTH.

By G. Greenhill.

The parabolic trajectory enunciated and investigated by Galileo, 1623, is still employed in elementary dynamics as an introduction to the motion of shot through the air. It replaced the ancient gunner's theory of a trajectory composed of a *motus violentus*, and a *motus naturalis*, connected by a *motus mixtus* (Santbech, 1471).

In this *motus violentus*, *naturalis*, and *mixtus*, described by Thomas Digges, *Pantometria*, 1591, "The bullet violently thrown out of the piece by the furie of the poulder hath two motions, the one violent, which endeavoureth to carry the bullet right out of his diagonale, according to the direction of the piece's axis, from which the violent motion proceedeth; the other naturale in the bullet itselfe, which endeavoureth still to carry the same directelye downeward by a right line perpendicular to the horizon, and which dooth, though insensiblye, even from the beginning of little and little draw it from that direct and diagonale course. These middle curve arkes of the bullet's circuite, compounded of the violent and natural motions of the bullet, albeit they be more helicale, yet have they a very great resemblance to the Arkes Conical. But in randoms above 45 deg. they do much resemble the hyperbola, and in all under the ellipsis. But exactly they never accorde, being indeed spirale mixte and helicale." Digges is here writing a translation and commentary on Tartaglia's *Nova Scientia*, under the name of the "Newe Science of Great Artillerie," and making a random guess that the trajectory may be assimilated to a parabola, ellipse, or hyperbola, as Newton did also in the *Principia*. Digges is endeavouring also to explain the refutation given by Tartaglia of the fallacy not yet extinct, that the trajectory is a straight line for a certain distance at the outset, still called the "point blank" range (bout-portant, but-blanc).

In the *motus violentus* of the bullet, "wherein she flieth violently through the furie of the poulder," the motion was taken swift and straight, as gravity had no time to curve the path; the extent of the *motus violentus* survives in the expression "point-blank range." In the *motus naturalis*, the original impetus was taken to be annihilated by the air resistance, and the shot arrived dropping vertically. The *motus mixtus* between was filled in by hand as a connecting curved link; although in the diagrams of Santbech, 1471, there is no curved *motus mixtus* shown (Fig. 1) in a trajectory of mortar fire or of a football. With his imperfect powers of observation, this was as near as the old gunner could guess the appearance of the facts, and give his explanation of them.

Galileo replaced this artless theory of ancient artillery science by an appeal to the ideal conditions of rational mechanics. Ignoring air resistance, he proved that the track of a shot in the air would be a parabola, as he could show off experimentally to a class by rolling a ball across a sloping desk. Take a little steel sphere, such as that of a bicycle ball bearing, as suitable for the purpose.

Galileo in his turn was taken too much at his word; and assuming that his parabolic theory was correct even in a resisting medium of the air, the calculated velocity of the shot came out much too low for the facts. Even when an attempt was made to allow for air resistance, the estimate was based on Newton's experiments at low velocity, of dropping in the dome of St. Paul's, glass globes filled with mercury and air, experiments repeated with bladders of air by Desaguliers about 1710.

The authority of Newton was so paramount as to allow no dispute, either on air resistance, or the possibility of an achromatic combination of lenses. So that when Benjamin Robins invented his ballistic pendulum, 1740, and his experiments showed that Newton's estimate of air resistance required to be trebled when the velocity of sound was exceeded, Robins was held up to opprobrium as a heretic for daring to impugn an opinion emanating from Newton, and canonised by his authority.

The rival professor, Muller, of the Royal Military Academy, Woolwich, came to the defence of Newton, and in his official text-book he taught that it was impossible for a shot to acquire a velocity of more than 920 ft. per second. Muller writes: "The learned professor Euler commits the same error as his author, Robins, in his comment on Robins's work in his table of velocities, making them much greater than they possibly can be. Thus for instance when the piece is 22 calibres long, and loaded with half the weight of the shot, he finds 1,477 Rhinland feet, or 1,521 English, moved over in 1 second; whereas we prove that this velocity can never amount to 914·7 ft. in a 42-pounder, and consequently much less in a smaller calibre."

Time, the improver, has shaken all these ideas down into their proper place, and the original estimates of air resistance determined by Robins are found useful to-day in calculating terminal velocity, as in bomb-dropping.

The calculation of a trajectory, when air resistance is taken into account, is not a simple matter, whether of a rifle bullet up to a range of 1,000 yards, or of an artillery shell sent to a distance of 12 miles, 20 miles, 25 miles, or even 75 miles to-day.

In the rifle bullet the relative effect of air resistance in causing retardation is much greater, as it may amount to some 20 to 40-fold gravity at the start, and so the trajectory falls very far short of the parabolic curve. An artillery shell may feel a resistance two or three times gravity in the air strata near the ground, but the diminution of velocity and air density conspire to diminish this effect in rising high from the ground, so that the old parabolic theory is a useful assumption in a

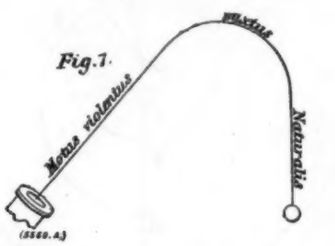


Fig. 1.

preliminary calculation, especially of the mid part of the trajectory, where the shot may be sailing along for miles at a height of 3 miles to 20 miles up in the air, in the attenuated strata.

But here Muller comes in again with his animus against Robins: "The velocity v must always be less and can never be equal to the greatest velocity the ball may acquire in that medium (the terminal velocity), and consequently the resistance of the body arising from its motion in the medium can never equal, much less exceed the weight of the shot, as has been erroneously supposed by some authors." "The common estimation of the resistance of bodies moving in the air is quite void of truth, at least as Mr. Robins will have it; for he makes that of a 24-lb. ball above 23 times more than it possibly can be, as we have proved in this work," the official treatise for use in the Royal Military Academy, Woolwich.

In dealing with these long ranges and a trajectory for the most part in the attenuated region of the atmosphere, the parabolic theory of Galileo must not then be ruled out as obsolete, as it can give useful information of limits to be expected, high and low; and a trial trajectory may be run out on Galileo's theory, to be corrected and tuned up in a closer approximation where the air resistance becomes important, and is taken into account, with every refinement of tenuity theory. For although air density dies out at something like compound discount with the height, it is not to be considered zero, as its existence is revealed by the meteorites, fired and volatilised by the friction, high up before reaching the ground.

A *ne plus ultra* stalemate draw was declared by artillery authority some thirty years ago, after some experiments at a range of 12 miles, disparaged as of no military utility. Such opportunism in State management is death to invention and initiative. To-day we see how artillery science is only just beginning to make a new start, and all preconceived tradition of best and perfection has gone by the board under the stimulus of the scourge of war.

The realised range of 75 miles is a mere stepping stone to 100 miles and more; and here the parabolic theory of Galileo begins to break down, and will require to be replaced by Newton's elliptic theory, in the "Problem of Two Bodies," chief subject of his *Principia*.

A correspondence beween Newton and Hooke, concerning the easterly or westerly deviation of a body, falling from a great height like a bomb, reveals that Newton's first conjecture of an elliptic orbit was employed in his explanation.

But Newton's main investigation was undertaken in the astronomical interest, as a justification of Kepler's "Three Laws of Planetary Motion," when explained and interpreted as the result of Universal Gravitation, the force of attraction between any two bodies, as Sun and Earth, Earth and Moon, varying inversely as the square of the distance.

Kepler's Laws, 1609, are given here to show how Newton theorised upon them (*Principia*, Book III), but not so carefully as Maxwell in his "Matter and Motion," where his version of the laws is quoted.

I. A planet moves in an ellipse having one focus in the centre of the Sun.

II. The area swept out by the radius vector from the Sun to a planet is proportional to the time of describing it.

III. The square of the periodic time (the planet's year) is proportional to the cube of its mean distance from the Sun.

Kepler based these laws on astronomical observations, chiefly those of Tycho Brahe on the planet Mars, as his elliptic orbit has considerable ellipticity. The laws are purely kinematical, and their dynamical interpretation was undertaken by Newton, and explained further by Maxwell in "Matter and Motion," Chapter VIII.

Kepler's Law III is confirmed by a mere numerical calculation applied to all the planets of the solar system, after an observation of their periodic time, or year, and mean distance from the Sun.

We may suppose a verification of the first two laws to be undertaken from our observation of the Sun, as recorded in the "Nautical Almanack." Here it is found that:—

1. The variation of the angular diameter d of the Sun, or his time of passing the meridian, can be expressed in a formula:

$$d = D(1 + e\cos\theta) \quad . \quad . \quad . \quad (1)$$

in which D denotes the mean angular diameter, about 32 min., a little over half a degree, and θ the longitude from perihelion, e being a small constant, about $1 \div 60$, such that:

$$e = \frac{D_1 - D_2}{D_1 + D_2}$$

where D_1, D_2 denote the greatest and least value in the year of the angular diameter; and in the Nautical Almanack,

$$D_1 = 32' 36'', \quad D_2 = 31' 32''.$$

So also the Parallax of the Sun, the semidiameter of the Earth as seen from the Sun, will fluctuate to the same ratio as D_1 to D_2, between 9″ and 8·7″, having an arithmetic mean 8·85″; but the harmonic mean 8·8″ is the parallax at mean distance.

The formula proves Law I, that the relative orbit of the Earth and Sun is an ellipse of eccentricity e given in polar co-ordinates by:

$$\frac{l}{r} = \frac{d}{D} = 1 + e\cos\theta \quad . \quad . \quad . \quad (2)$$

II. The hourly advance of the Sun in longitude, or the angular velocity ω of its radius vector, is proportional to the apparent area or square of the diameter; so that:

$$\omega = \frac{d\theta}{dt} \propto D^2 \propto \frac{1}{r^4}, \quad r^2\omega = h \quad . \quad . \quad (3)$$

a constant, twice the rate at which sector area is swept out by the radius vector.

Theorising on Kepler's laws in their generality, Newton inferred from Law II that there is an attraction between the Sun and the Earth, or a planet; and then from Law I that the attraction must vary inversely as the square of the distance; while Law III showed that the attraction between the Sun and a planet was not selective, but of the same nature for all planets; and thence generally

throughout space between two particles of matter in the universe, irrespective of quality. The most perfect experimental test is the easy one given by Newton, of a simple pendulum or plummet on the end of a thread; the pendulum beats the same whatever the weight or material of the bob.

The eccentricity of a planetary orbit is usually so small that the orbit round the Sun may be considered circular; and then Kepler's Law III, applied to circular orbits, implies an attraction varying inversely as the square of the distance, and so affords an independent testimony to the Law of Gravitation. The inverse square law, first enunciated by Borelli, is the natural one to assume, by analogy with other emanations from a centre, as of sound, light or smell.

1. In the "Problem of Two Bodies" a calculation is made of the relative motion of two celestial bodies in free space under their attraction of gravitation, the Sun, for instance, weighing S grammes, and a single planet weighing P grammes, attracting with a force of $F = G\,S\,P\,r^{-2}$ dynes at a distance r cm, causing acceleration $G\,P\,r^{-2}$ and $G\,S\,r^{-2}$ in S and P, and therefore a relative acceleration $G\,(S+P)\,r^{-2}$ cm/sec², G denoting the Gravitation Constant, taken in round numbers at 666×10^{-10}. (We are working here in the metric C.G.S. system of units, as suitable in a cosmical problem.)

The relative orbit of S and P is then a conic section, in which from (2), (3):

$$G\,(S+P) = \frac{h^2}{l} = n^2\,a^3 = \frac{4\,\pi^2\,a^3}{T^2},$$

$$F = 4\,\pi^2\,\frac{S\,P}{S+P}\,\frac{a^3}{T^2\,r^2} \quad . \quad . \quad . \quad (4)$$

the algebraical expression of Kepler's Law III, as amended by Maxwell, "Matter and Motion," page 114.

If a model orrery could be made to geometrical scale in space of this celestial system of two bodies, the Sun and a planet, moving under their gravitation alone, then since S and P are proportional to the mean density and the cube of the diameter a^3, Kepler's Law III asserts that T varies inversely as the square root of the density, so that the two systems, full size and orrery, will always remain similar, if the density is unaltered, or else made inversely proportional to the square of the periodic time. The same theorem may be asserted of a model orrery of the solar system, when planetary perturbation comes into account; this appears in Newton's statement of Mechanical Similitude in the *Principia*, lib. II, Section VII.

2. Suppose for example that the bodies S and P were alone in free space a great distance apart and approaching with relative velocity V cm/s, so as in the absence of gravitation to pass at a minimum distance d cm, like two ships at sea.

When the bodies arrive within the sphere of their mutual influence, the attraction becoming appreciable, the gravitation changes the relative orbit from an apparent straight line into an hyperbola, of which one asymptote is the original relative straight path; and then after coming to a minimum distance due to the attraction the bodies will recede again, so that the final relative path is the other asymptote. The direction of relative motion will be turned through $2\,a$, the angle between the asymptotes, such that:

$$l = d\cot a, \quad G\,(S+P) = \frac{h^2}{l} = \frac{d^2\,V^2}{d\cot a},$$

$$\tan a = \frac{G\,(S+P)}{d\,V^2} \quad . \quad . \quad . \quad (5)$$

the modified form of Kepler's Law III for the hyperbolic orbit, where the Third Law cannot state a case; $2\,d\tan a$ being the transverse axis; and the minimum approach will be reduced from

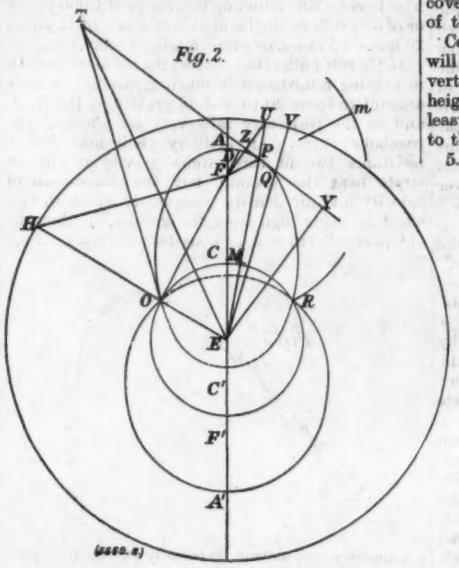
$$d \text{ to } d\,(\sec a - \tan a) = d\tan(\tfrac{1}{2}\pi - \tfrac{1}{2}a)$$

Thus the hyperbolic orbit may be considered as the more natural to be encountered among bodies sparsely scattered in space; it has been observed in some comets, and would result in the meeting of two remote solar systems, or the appearance of a new star. The ordinary elliptic orbit of a planet in our solar system must be supposed to arise in a different way, as in the condensation into drops off a nebular vortex, or in a series of projectile bodies thrown off a central Sun, or a planet like Saturn, in a satellite ring.

3. We are concerned here not with the motion of the earth or a planet round the sun, but of a shot projected from the surface of the earth, with such a high velocity as to describe a trajectory long enough to be considered a satellite orbit, an ellipse about a focus at the centre of the earth; as of a meteorite missile flung at our earth from the depth of outer space; or of a rock discharged from a volcano; and in the investigation we utilise the theory laid down by Newton in the "Problem of Two Bodies." We adopt the synthetic geometrical treatment, as given by Maxwell in "Matter and Motion," Chapter VIII., but apply it to the long range of a shot over the earth, instead of the sun and a planet.

The shot is projected from a gun at O with velocity V, such that turned vertically upward the shot would reach a height H (Fig. 2). For any other direction, the trajectory will be an ellipse; one

Fig. 2.



focus will be at E, the centre of the earth, and EH will be the length of the major axis; so that the other focus F lies on a circle (or sphere) centre O, and radius OH. For the geometry of the ellipse refer to the figure of p. 111, "Matter and Motion"; and let O A P Q R in our Fig. 2 be an elliptic trajectory, focus at E and major axis EH, with the geometrical property that the sum of the focal distances is constant,

$$FP + PE = FO + OE = HO + OE = HE = EU,$$

$$FP = PU \quad . \quad . \quad . \quad . \quad (5)$$

The tangent at any point of an ellipse bisects the angle between the focal distances; so that the tangent at O is perpendicular to FH and at P to FU; and if these tangents intersect in T, ET bisects the angle OEP, or the tangents TO, TP subtend equal angles at the focus E, another geometrical property of the ellipse; also FT bisects OFP.

If FU cuts the tangent at P in Z, $FZ = \frac{1}{2}\,FU$ and is perpendicular to the tangent; and if EY is the perpendicular from E, Kepler's Law II, $r^2\,\omega = h$, is equivalent to $v.EY = h$, if v denotes the velocity at P; so that, since $EY.FZ = b^2$,

$$v = \frac{h}{EY} = \frac{h}{b^2}\,FZ = \frac{1}{2}\frac{h}{b^2}\,FU \quad . \quad . \quad (6)$$

Thus the velocity v at P is proportional and perpendicular to FU, so that the circle HU may be taken as Hamilton's Hodograph of the orbit, such that the acceleration of P is proportional to the velocity of U, and perpendicular to it, that is in the central direction UPE.

With PQ the arc of the ellipse described in unit time, then UV represents the acceleration; the acceleration of P is then proportional to the angular velocity $\omega = h\,r^{-2}$, and this is inversely as the square of the distance EP, and it is in the direction PE. This is the geometrical demonstration given in "Matter and Motion," § 132.

4. For a given range OR over the earth, OF bisects the angle OER; and if EF cuts the circle HF again in F', then OT, OT' perpendicular to HF, HF' will give the two directions to shoot so as to range to R, one for high-angle fire OPR, the other for direct fire OP'R (provided it can clear the intervening ground), elliptic trajectories with a common focus at E, and F, F' the other focus.

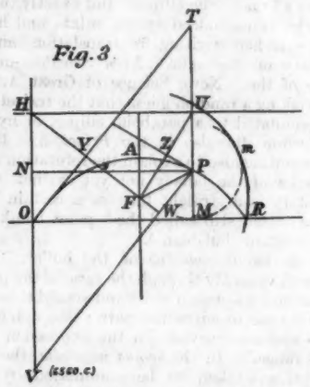
The maximum range OR_m is obtained by making the angle OER_m double the angle OEG, where EG is tangent to the circle HF; the angle of elevation a is now EHG, and EOG is $2\,a$, $\cos 2\,a = OH \div EO$, requiring a figure in which OH is less than EO.

Then $OER_m = 180° - 4\,a$; so that if a is given in degrees, the maximum range OR_m over the earth is $60\,(180 - 4\,a)$ geographical miles. The two elliptic trajectories of high angle and direct fire coalesce into a single ellipse with focus at G, so that the chord of the maximum range OR_m is the latus rectum of the corresponding elliptic trajectory; and the area covered is $\pi.OR_m^2$, the fraction $(OH/OE)^2 = \cos^2 2\,a$ of the surface of the earth.

Conversely, the least velocity of projection that will send a shot from O to R_m, is that which turned vertically upward, will send the shot to a vertical height, $OH = \frac{1}{2}\,OR_m$. Thus, for example, the least velocity that will send a shot from the pole to the equator will make $OH = \frac{1}{2}\sqrt{2}\cdot OE$.

5. If OH = OE, the shot will have the grazing

Fig. 3.



velocity G required to make it skim round the earth like a satellite turned horizontally; and turned at any other angle β minutes with the vertical, the shot will range $2\,\beta$ geographical miles, OR being the minor axis of the elliptic trajectory.

If OH is greater than OE, the two trajectories, free in the air to have the same range OR, will go round the world opposite ways, as drawn in Fig. 2.

When OH is infinite, the parabolic velocity P is obtained and with G = 15,300 knots, $P = G\sqrt{2} =$ 21,600 knots, about one million cm/s; a parabola will be described with focus at E, and the shot leaves the earth never to return, but flung into outer space. If the parabolic velocity P is exceeded, the trajectory is an hyperbola.

Produce OF to meet the elliptic trajectory OAP in D; then

$$OD + DE = OF + FD + DE = OH + HE,$$

so that the ellipse touches an enveloping ellipse at D, which has E and O for foci, and a vertex at H; the space inside the spheroid swept out by the revolution of this ellipse about EH will contain the points within range of a gun at O, which can shoot vertically with impetus to carry up to H; points outside this spheroid will be out of range.

6. If O is at a pole of the earth, the vertical plane OP of the trajectory will preserve a fixed direction in space with respect to the stars, while the earth turns round; so that the shot will strike at R not in the original meridian of projection.

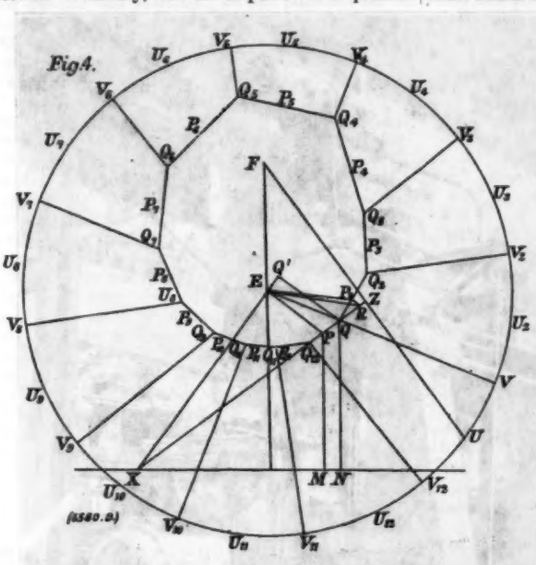
Projected horizontally over a perfectly smooth sheet of ice at the pole, with velocity K knots, a body will reach a distance 12K miles in 12 hours, but will strike a point on the opposite end of the diameter that was aimed at; and over the ice will describe a spiral of Archimedes.

Deflection for speed of diurnal rotation becomes important in these long-range trajectories, and no simple formula can be written down for all the

various conditions. But with the present limited power of artillery, a working rule can be constructed by supposing the vertical plane of the trajectory to follow a rising or setting star near the horizon, in the same way as a Foucault pendulum.

The horary motion in azimuth of a star near the horizon is 15 deg. (sin. lat.), so that with a time of flight of t seconds (sidereal) the deflection of the ground past the trajectory would be 15 deg. t (sin. lat.), or $\frac{1}{4}$ t (sin. lat.) minutes, from west to east, to be corrected by the same number of minutes of easterly deflection given on the back-sight to the left.

7. Returning for a moment to Galileo and his parabola, in a field of uniform gravity, the focus E recedes to infinity, and the impulse UP is parallel



to AF; the circle HU is of infinite radius and a horizontal straight line, the directrix of the parabola (Fig. 3), and FO = OH, FP = PU, geometrical definition of the parabola as locus of a point P which moves so that its distance from a focus F is equal to its distance from a straight directrix HU.

But in the ordinary method of the text-book of Elementary Dynamics, with a body discharged from O with velocity Vf/s in the direction OT, and reaching T in the absence of gravity in t seconds, OT = Vt feet. Let fall from O, the body would reach V in the same time t, OV = $\frac{1}{2}$ gt^2; and, in the language of the gunner, OT would be the *motus violentus*, and TP = OV the *motus naturalis*.

Galileo combined these two motions into a *motus mixtus* along the curve OAP, where, eliminating t,

$$\frac{OT^2}{TP} = \frac{V^2t^2}{\frac{1}{2}gt^2} = \frac{2V^2}{g} = 4OH \quad . \quad . \quad (8)$$

supposing the shot would reach to the height H if the velocity V was turned vertically upward.

To translate Galileo's relation into the geometrical property of the parabola above, a few steps of geometry will be enough, and so may replace a separate study of the parabola in Geometrical Conics.

Produce HF to cross PV in W, and draw PN horizontal to meet OH in N. Then from the property of similar triangles:

$$\frac{PV}{PN} = \frac{HO}{HY} = \frac{OV}{YW} \quad . \quad . \quad . \quad (9)$$

and with

$$PV^2 = 4HO \,.\, OV \text{ in } (8)$$

$$PN^2 = 4HY \,.\, YW = (HY + YW)^2 - (HY - YW)^2 \quad (10)$$

$$= HW^2 - FW^2 = HP^2 - FP^2$$

$$FP^2 = HP^2 - PN^2 = PU^2, FP = PU \quad . \quad (11)$$

Produce FP to meet in m the circle drawn with centre F through O and R.

$$Fm = FR = UM, FP = PU, PM = Pm \quad (12)$$

as in the elliptic trajectory in Fig. 2.

8. In a finite step PQ in Fig. 2, of P to Q, and U to V, the velocity communicated which changes the velocity at P to that at Q, is still given by $\frac{\frac{1}{2}h}{p}$ U V, and this change may be supposed communicated in a single blow along the radius to E bisecting the angle PEQ.

This suggests a geometrical demonstration of the property of the orbit, supposing in Newton's manner the incessant central force is replaced by a series of equal intermittent impulses, acting at equal angles round E. Consider then a body moving in free space under no force, except when it crosses a ray of a pencil system, emanating from a fixed centre E at a constant angular interval in a plane, when it receives a central blow of constant magnitude, giving a constant change of velocity.

The hodograph is here a series of discrete points, U, U_2, U_3, ... in Fig. 4, arranged at equal distance round a circle with centre at E, and such that the vector from F to U, U_2, U_3, ... is proportional and perpendicular to the velocity with which the body crosses the ray EU, EU_2, . . ., and the equal chords UU_2, U_2U_3 . . ., represent the velocity communicated by each blow, each bisecting the chord at right angles.

The blow changing the velocity from FU to FU_2 is supposed to act when the body crosses the ray EQV, bisecting the angle UEU_2; so that starting from the point P in the direction PZ, bisecting FU at right angles and tangent to an ellipse with foci at E and F, and major axis EU, the body on arrival at Q will have the velocity changed to the direction QP_2Q_2 at right angles to FU_2.

Starting at P, where FP = PU, then at Q, FQ = QU = QU_2; so that QQ_2 bisects FU_2 at right angles; and on arrival at P_2 where the body crosses EU_2, $FP_2 = P_2U_2$; so that QP_2 touches the same ellipse at P_2. Continuing in this manner, a polygonal path, Q Q_2 Q_3 . . . . is followed by the body, circumscribed to this ellipse, with focus at E and F and major axis EU. This polygon can be shown by paper folding, doubling over each U point in turn to come over F. The polygon is inscribed at the same time in another ellipse, having the same focus E, and corresponding directrix; but F is no longer the second focus. For if EX is drawn at right angles to EP to meet the tangent ZP in X, the perpendicular from X on EF will be the directrix of the focus E.

Draw QQ perpendicular to EX, and denote the angle UEU_2 by 2 α, so that $EQQ' = \alpha$; then

$$\frac{EQ}{QX} = \sec\alpha \,\frac{QQ}{QX} = \sec\alpha \,\frac{EP}{PX} \quad . \quad (13)$$

or if PM, QN are the perpendiculars on the directrix, and e denotes the eccentricity of the ellipse PP_2 . . .,

$$\frac{EP}{PM} = e, \frac{EQ}{QN} = e\sec\alpha$$

so that Q lies on an ellipse with the same focus E and directrix XMN, but with eccentricity $e \sec \alpha$.

Inside an oval billiard table a polygonal path would be realised, and with perfect elasticity would circumscribe a confocal ellipse.

The spider-web appearance of the diagram (Fig. 4) could be realised by stretching a series of threads radiating from E at equal angular interval, and to the same tension; and then knotting over them the polygon of thread Q Q_2 Q_3 . . ., circumscribed to a conic with focus at E and F. On cutting away the threads interior to the polygon, no change will take place in shape, and the tension of a thread of this funicular polygon will be proportional to the velocity with which it was described previously, a statical analogue. This procedure is very similar to that employed by the spider in making her web.

(To be continued.)

Gas Traction Committee.—Professor W. Ernest Dalby, F.R.S., has consented to serve on the Expert Sub-Committee of the Gas Traction Committee in the place of the late Colonel Bertram Hopkinson, F.R.S.

CANADIAN VICKERS' SHIPBUILDING WORKS AT MONTREAL.

The re-awakening of interest in Canada in the shipbuilding and engineering industries some years ago came at an opportune time, in view of the world war, as now the various establishments organised are doing most useful service, not only in the production of ships at a time when this is one of the primary elements in the achievement of victory, but in the supply of munitions for the fighting forces. The programme of the Imperial Government provides for the building in Canada of 43 steel ships of a tonnage of 211,300 deadweight, and 46 wooden ships of 128,800 tons deadweight, the former costing 8,000,000*l.* and the latter nearly 5,000,000*l.*, or a total of nearly 13,000,000*l.* Already much work has been done. The Dominion Government has provided for an appropriation of 5,000,000*l.*, which may be considered as a first instalment. The full effect of the development will not be realised for some months yet. It is hoped, however, that next year there will be commissioned 50 new ships of 235,000 tons, most of them of standard types, of which three have been arranged for, respectively 3,000 tons, 5,000 tons and between 8,000 tons and 10,000 tons. Thus it is hoped that by the end of 1919 Canada's contribution to the shipping fleet available for the Allied cause will be 575,000 tons. Much of the steel is obtained from the United States Shipbuilding Board, but an increasingly large proportion is now manufactured within the Dominions, so that an indirect result of the present demands for shipping will probably be the placing of the shipbuilding industry of Canada on a sound economical basis.

One of the leading establishments is that of Canadian Vickers at Montreal, the erection of which was commenced early in 1910, but it was not until the beginning of the year 1915 that the establishment was able to exercise full influence on the shipbuilding resources of the Dominion. We have, in a previous volume, given illustrations of the development of the works,* which involved the investment of nearly 2,250,000*l.* and the utilisation of 35 acres of land. We now reproduce, on Plates XXXI to XXXIV, a series of photographs illustrative of the progress of the works and of the war work undertaken. These illustrations deal almost exclusively with merchant shipbuilding, with the exception of the photographs, on Plate XXXI, of high-speed motor boats, of which a great fleet has been built. In addition, however, the company, in their various machine shops, have undertaken and carried out the manufacture of a large number of projectiles.

As to the motor boats illustrated on Plate XXXI, it is not permissible to enter into details. As indicating that the resources of the establishment were utilised completely, it may be stated that the great floating dock which forms such an interesting feature of the equipment of the establishment, and is shown on Fig. 5 of Plate XXXIII, was roofed in to provide a workshop for the building of these boats. In this way, 30 boats could be in progress simultaneously within the dock, while others were built in other departments on the shore. The general characteristics of the boat are well shown in Fig. 2, on Plate XXXI, which also illustrates the method of transporting them overland to a convenient Atlantic port. It will be seen that the boats were loaded on exceptionally long and well trussed trucks, with a four-wheeled bogie at each end, the bow and stern of the boat overhanging corresponding bogies. These bogies had a capacity of 30,000 lb., the tare being 30,200 lb.

On Plate XXXII, two illustrations are given of a ladder twin-screw dredger, the largest ever built in Canada, designed for operation in the North Channel of the St. Lawrence. Of this dredger we intend to publish detail drawings in a later issue, so that we may content ourselves here with stating that the dredger is constructed to operate to a depth of 55 ft., and is of the hopper type, but is equipped with shoots for discharging into barges.

The view of the dredger on the launching ways gives some idea of one of the building berths. This berth can accommodate ships up to 500 ft. in length, while the width is 105 ft. and the clear

* See Engineering, vol. xcix, p. 187.

height of the shed 87 ft. Thus two ships may be built side by side. There are five other closed-in berths for vessels up to 700 ft. in length. The vessels built in all these berths are launched into a basin, shown in Fig. 5, on Plate XXXIII, normally occupied by the floating dock, the building berths being to the right of the view, although not seen. As this basin is kept free of ice floes by a barrage across the entrance, it is possible to launch at all seasons except when the river is ice bound. But, as all the berths are adequately provided with electric cranes of large capacity, the boilers and auxiliary machinery, can be put on board before the vessel is launched, thus affording a large range in the time within which a vessel need be launched, so that the ice on the river does not in any way delay the construction of the vessels. Indeed, it is a question whether, after all, the retention of a ship on the building berth for as long a period as possible does not tend to shorten the time for ultimate completion.

Fig. 6, on Plate XXXIII, illustrates berth No. 3, and Fig. 7, on the same Plate, berth No. 4; in both these berths standard ships are being built. These standard ships correspond almost exactly to those built in this country under the direction of the Admiralty, and, as a rule, six are simultaneously in course of construction at the Montreal works. Some are to the order of the British Admiralty and others for the Canadian Government. It is anticipated that the production this year will be 70,000 tons, which is particularly satisfactory in view of the fact that these are the first ocean-going steel cargo ships built in Canada, and completely equipped, in one yard, with engines, boilers, auxiliary machinery and all fittings, manufactured in Canada, the exceptions being some of the steel plates, the boiler furnaces and the anchors. Some idea of the capacity of the auxiliary department is found in the fact that 15 cargo winches are being produced per week, in addition to steering gears, telemeters, and anchor windlasses for ships built within the establishment or elsewhere.

At the inception of the scheme for shipbuilding it was decided also to construct engineering and boiler shops—as well as electrical shops and auxiliary machinery shops, with all the necessary machine-tool equipment—so that the vessels could be completed ready for service. Fig. 8 shows the boiler shop at a recent date. In this connection it may be said that the original boiler and engine shop was 380 ft. by 155 ft., arranged in three bays, respectively 65 ft., 51 ft. and 39 ft. For a considerable time after the outbreak of war these were utilised largely for the manufacture of projectiles, the battery of hydraulic presses in the smithy being very serviceable in connection with the forging operations. The engine and boiler shops, however, have since been considerably extended, in order to increase the output of merchant ship machinery. The view in Fig. 8 gives a fair indication of its size. It will be seen that water-tube as well as cylindrical boilers are constructed, various elements of the Howden system of water-tube boilers being seen in the foreground. This type of boiler is extensively manufactured at the Canadian Vickers' Works, but as we hope, in an early issue, to publish drawings of the boiler, we may defer our description of the system. In addition to the boilers for the standard ships built in the establishment, 28 of the same type, required for vessels built elsewhere in Canada, were completed at these works. Fig. 9, on Plate XXXIV, and Fig. 10, on the present page, illustrate the engine shop and the standard type of marine engine fitted into the standard cargo vessels now in course of construction. A description of a typical ship with her machinery will be given presently.

Not only has considerable work been done in the construction of new vessels, but the establishment has been specially utilised in connection with repair work. A notable job was the overhaul and repair of two British cruisers which included the machining of a main crankshaft, not by any means a simple operation. But as the design of the lathes was treated on a broad principle at the inception of the scheme, there was not much difficulty in carrying out the work. The shaft dealt with was 17 in. in diameter, with a length of 42 ft., in two 21-ft. lengths, each with two throws; the machine which undertook the work was of very considerable size. In addition to the cruiser repairs, many mine-sweeping trawlers, drifters, &c., have been overhauled and repaired. An important item in the repair department is the floating crane used at the works. This crane, which has a lifting capacity of 75 tons, we intend to illustrate and describe in our next article.

In Fig. 5, there is seen the floating dock, which we illustrated and described when it was built (see Engineering, vol. xciv, page 228). It has a length over the platforms of 600 ft., a width overall of 135 ft., and a depth at pontoon centre of 17 ft. As the ends are open, it can take a ship of any length, the lifting capacity being the only limit, and this is 25,000 tons. The side walls are 470 ft. 6 in. long, with a height above the pontoon deck of 42 ft. The dock is completely equipped, and has proved of great service in connection with the shipping in the St. Lawrence River. The crane on the side walls is of the electric travelling gantry type, and has a lifting capacity of 3 tons.

On page 406 we give illustrations of the largest sea-going cargo steamer built in Canada. It recently left the Canadian Vickers works. The dimensions are as follow: Length between perpendiculars, 380 ft.; breadth moulded, 49 ft.; depth moulded, 30 ft.; load draught, 24 ft. The vessel is a single-screw steamer of the single-deck type with poop, bridge and forecastle, built to Lloyd's highest class. The machinery is fitted amidships. The framing is on the transverse system with stringers omitted. Pillars are widely spaced and holds generally clear of obstructions. A double bottom is carried all fore and aft arranged and subdivided for water ballast. Fore and after peaks are also arranged for water ballast. Side bunkers are provided abreast the boiler room with reserve space for coal in the bridge 'tween decks. The cargo hatches are of large area, each provided with two 5-ton derricks and two 7-in. by 10-in. cargo winches. A separate donkey boiler is carried for supplying steam to the auxiliaries. The officers and engineers are accommodated in houses on the bridge deck and the crew housed in separate compartments under the poop.

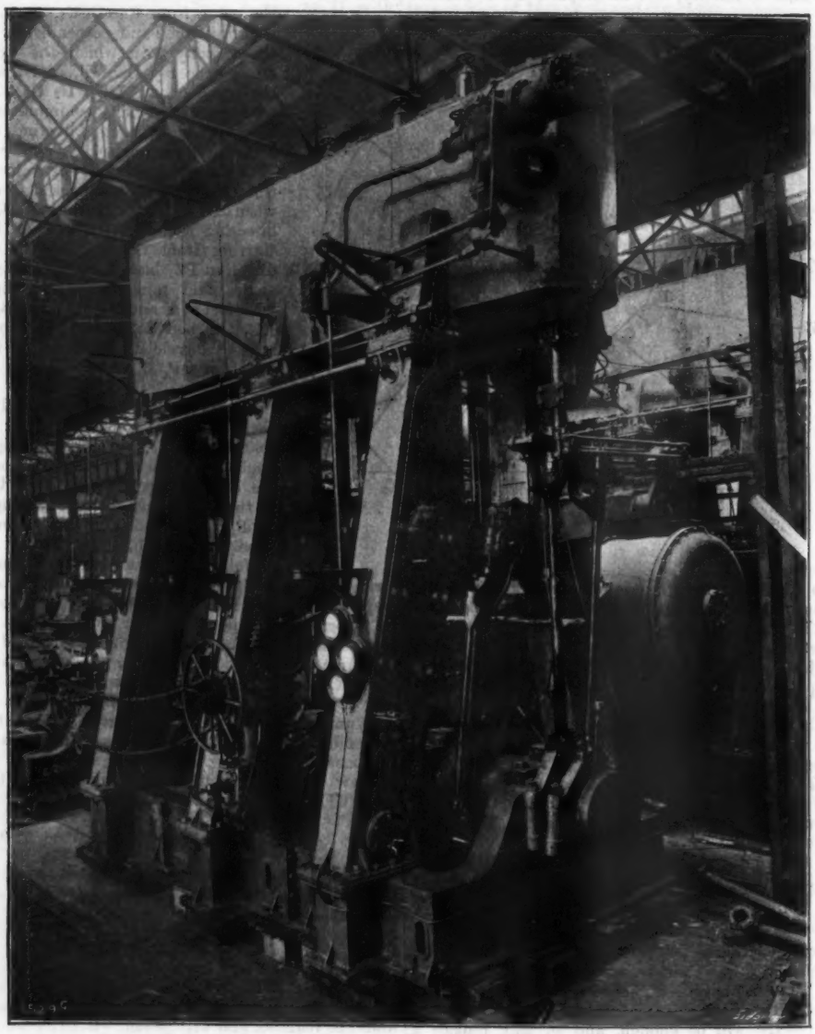


Fig. 10. Standard Engines for Cargo Steamers.

The machinery is typical of the standard sets for single-screw cargo steamers. An inverted vertical direct-acting triple expansion engine. The diameters of cylinders are: High pressure, 25 in.; intermediate pressure, 41 in.; and low pressure, 67 in.; the stroke being 45 in. The cylinders are supported on cast-iron columns at the front and back, the condenser being separate, cylindrical, and bolted on to the back columns. The pumps are worked by means of levers and links from the low-pressure cross-head. Steam is supplied by two single-ended cylindrical boilers, 16 ft. diameter by 11 ft. 3 in. long, each fitted with three furnaces and worked under natural draught conditions. The boilers are constructed for a working pressure of 180 lb. per square inch. The usual auxiliary machinery is supplied, consisting of evaporator, feed heater, feed engines, ballast pump and general service donkey.

The machinery throughout is built to fulfil the Norwegian Board of Trade and Lloyd's requirements, and is of substantial construction as usually fitted in ocean-going steamers of this type.

(To be continued.)

GASPARD MONGE—1746–1818.

In the calendar of science Monge may be regarded as the patron of draughtsmen and, just as the ceiling of the amphitheatre of the Sorbonne is inscribed with the names of the founders of chemistry, so might the entrances to our drawing offices appropriately bear the names of Monge and Hachette. Of descriptive geometry, the basis of mechanical drawing, Monge was the creator, while to Hachette, his disciple and assistant, we are indebted for its development and application to practical work. This, of all the gifts bestowed upon engineering by the mathematicians, has been one of the most valuable. "Descriptive geometry," wrote Monge "has two objects: first, it supplies the means of representing on a sheet of paper in two dimensions bodies of three dimensions provided always that these bodies can be vigorously defined and, secondly, it gives the power of recognising the forms of bodies by the precise description given of them and of deducing all the truths resulting from their form and their respective positions." Thanks to official opposition, Monge was prevented from publishing his discovery, and he was in possession of his methods twenty years or more before he made them known publicly. Its first appearance was one of the fruits of the famous École Normale and École Polytechnique, opened in Paris in 1795. His first public lectures on the subject were delivered in those institutions, where Hachette was his colleague. His "Géométrie Descriptive" was published in 1800 and this was followed by the "Deux Supplements a la Géométrie Descriptive du Monge" (1811–18) and other works by Hachette, while another distinguished Frenchman who wrote upon the subject was Baron Dupin, who published, in 1813, a work entitled "Développement de Géométrie pour faire suite à la Géométrie Descriptive du Monge," and in 1819 an "Essai Historique sur les Travaux de Monge." Many years passed before any similar work appeared in the English language.

In our recent memoir of D'Alembert* we had occasion to refer to the remarkable group of eminent men of science France possessed during the latter part of the eighteenth century. Of that group Monge was one of the most prominent, and the record of his life is one of surpassing interest. Born in obscurity in the reign of Louis XV, he participated in the condemnation of Louis XVI., attained to wealth, honour and distinction under Napoleon, only in his old age to be dismissed and treated with ignominy by Louis XVIII. As versatile as a Rumford, he was not only a great mathematician and a savant, but was recognised as a capable organiser and man of affairs. Had he done nothing else than to assist in founding the École Normale and École Polytechnique he would deserve well of his country, but this work was but one item of his notable labours. The son of a small tradesman of Beaune, where he was born in 1746, by sheer force of genius he had at the age of 22 gained the chair of mathematics at the military school at Mézières. His name became known in Paris not only by his memoirs on the calculus but also by his mountaineering expedition with Darcet in the Pyrenees. In 1780 he was elected a member of the Paris Academy of Sciences. Three years later, the year of D'Alembert's death, he was transferred to the capital as examiner to the navy. Settled there, he found scope for all his energies. The soul of generosity, sympathetic, imaginative, he threw himself into all the movements of the day. Experience had made of him a reformer, and in him the popular demand for liberty, equality and fraternity found an ardent supporter. Intellectual activity and ferment surrounded him on all sides. Lalande, Delambre, Coulomb, Fourcroy, Laplace, Charles the physicist and Lacépède and Daubenton the naturalists were among his fellow workers in Paris at this time, as were also Bailly, Bochart de Saron Condorcet and Lavoisier, all of whom were to perish on the scaffold. To Monge as to so many others the fall of the Bastille appeared to herald an age of freedom. He joined the club of the Jacobins, was elected a deputy to the great National Convention, and in August, 1792, was appointed Minister of Marine. With Lagrange and Berthollet he was made a manager of the mint, and with Lagrange he assisted the deputy Romme draw up the remarkable Revolutionary Calendar which the French used from November 24, 1793, to January 1, 1806. Never an extremist and always, as Thiers calls him, a decided patriot, with Carnot, Fourcroy and Guyton de Morveau, Monge, on the memorable January 20, 1793, voted for the death of the king. In April of that year, when the Committee of Public Safety came into power, he resigned his office. Denounced to the Jacobins, he was for some time in peril of his life, but fortunately escaped serious molestation. Freed from his office of Minister of Marine he was now associated with his lifelong friend Berthollet, and with Chaptal in the organisation and improvement of the supply of munitions for the fourteen armies of Carnot. It was in this connection he wrote his memoirs on the manufacture of guns and of steel. After the fall of Robespierre and with the end of the Reign of Terror, more reasonable men came into power, saner counsels prevailed, and the National Convention turned to bring relief to their distracted country. To this period belongs the inauguration of the two famous schools we have referred to, and also the foundation of the National Institute, of which Monge was one of the original members. In 1796, Monge and Berthollet, with a party of artists, were sent to receive the works of art demanded from the fallen cities of Northern Italy. While thus engaged Monge became known to Napoleon, and on returning to France was commissioned by the young conqueror to carry to the Directory the text of the Treaty of Campo Formio. The acquaintanceship thus begun led to another expedition. In 1798, with Berthollet, Fourier, Hachette, Jomard, Girard and other learned men, he sailed from Malta with the army for Egypt. Monge and Berthollet appear to have been the daily companions of Napoleon throughout the campaign. They landed with him at Aboukir, travelled with him to Cairo, with him crossed the desert to Suez and tasted of water from the Wells of Moses, and finally with Napoleon and his generals Berthier and Andréossy sailed for France in the frigate Muiron, and landed at Fréjus in October, 1799. Once again settled in Paris, Monge resumed his work at the École Polytechnique and added to his labours there were those of the presidency of the Commission of the Arts and Sciences of Egypt. Under the Empire he received as many marks of distinction as he perhaps desired. The "Citizen" Monge became Count of Pelusium, he was given a seat in the Senate, made an officer of the Legion of Honour, and from Napoleon received an estate in Westphalia and a gift of 200,000 francs. He grew old, respected alike for his scientific achievements and patriotic labours, loaded with honours, only the more bitterly to feel the "slings and arrows of outrageous fortune." At the Restoration, he was by Louis XVIII dismissed from his professorship at the École Polytechnique and, amidst a storm of anger and indignation his seat in the National Institute was taken from him and given to Cauchy. The loss of that which was most dear to him was more than he could bear, his mind gave way, and like the unhappy Boscovich he ended his days under the dark cloud of mental derangement, dying in Paris July 28, 1818, at the age of 72.

Enough has been said to illustrate the life and character of Monge and the times in which he lived, and it is not our intention to further dwell upon his scientific work, important as it was. Bearing in mind, however, the prevailing sentiment of mutual regard of the French and ourselves towards each other to-day—a condition diametrically opposite to that obtaining in the time of Monge—we are tempted to recall a few interesting events from the annals of the two great schools of which we have spoken and which represent so characteristically the genius of the French nation. Though Coffinhal at the trial of Lavoisier might exclaim "la république n'a plus besoin de savants ni de chimistes," yet after the 9th Thermidor the National Convention entering upon a period of reconstruction, immediately applied itself to the reorganisation of the schools and colleges, many of which had been closed when the academies were suppressed in 1793. In September, 1794, the Committee of Public Instruction adopted a scheme for a normal school for Paris where instruction in the art of teaching should be given to persons already possessing scientific knowledge, and the following month the Convention passed a law establishing the "École Normale," explaining that "the term normal which was thus applied to the schools recently decreed is taken from geometry. It expresses really the perpendicular or level. In the sense employed it announces that all knowledge belonging to the sciences, to the arts and to the belle-lettres will all be taught and taught to all equally." The courses at the "École Normale" began January 21, 1795, and the school closed for want of money in the following May. Short-lived as it was, its influence was felt far and wide, and Biot, in his "History of Science during the French Revolution," compares the school to a "vast luminous column which rose so high from the middle of a desolate land that its great brilliancy covered France and enlightened the future." With equally noted colleagues in the chairs of history, morals and literature, Haüy was professor of physics, Berthollet held the chair of chemistry, Lagrange and Laplace lectured on mathematics, while Monge was professor of descriptive geometry. It was from notes taken at Monge's lectures here that we have the first account of the subject, though his discoveries date from about 1770. By a curious regulation the various professors at the "École Normale" had to "pledge themselves to the representatives of the people and to each other neither to read or repeat from memory," and the discourses were ordered to be taken down in shorthand in order to enable the deputies to see how the professors acquitted themselves. After closing its doors in May, 1795, the school remained shut till 1808. It was then again in being for fourteen years, was closed again in 1822 and re-opened in 1826. Under the title of the "École Normale Supérieure" it has been the scientific home and the scene of the labours of such as Sainte-Claire Deville, Tisserand, Hermite Lippman, Pasteur and Mascart.

While the École Normale as we have seen was designed to provide instruction in all branches of literature and science, the École Polytechnique was from the first an engineering school in which precedence was given to advanced teaching in the exact sciences. As a technical school it was by no means the first France possessed, for the "École des Ponts et Chaussées" founded in 1747 had, under the direction of the celebrated engineer Perronet, trained civil engineers for the public service before our own Telford was born. Then, too, there was the "École des Mines," also founded in 1747, and also the various schools of hydrography at Havre, Marseilles and other ports in which the modern science of naval architecture was cradled. Opened in 1794 as the "École des Travaux Publiques," its history under the name "Ecole Polytechnique" began September 1, 1795. Monge Carnot, Fourcroy, Guyton de Morveau and the deputy Prieur-Duvernois are all credited with a share in its foundation, but the presiding genius in the enterprise was undoubtedly Monge. That the school should at once have attained a preeminent position in France is not to be wondered at when the list of professors, assistants and students is examined. The labours of Lagrange, Legendre, Fourier, Prony and Monge, were seconded by those of men whose names are scarcely less famous in the history of science, while on the benches in its early days were to be found Lacroix, Fresnel, Poisson, Arago and Sadi Carnot. Just as the "Muséum d'Histoire Naturelle" was the acknowledged home of the naturalists, so was the Ecole Polytechnique, the recognised centre for the study of mathematics, and its "Journal" bears eloquent testimony to the high character of the work done there. Under Napoleon, to have passed with credit through the scientific and military courses was for the young and ambitious soldier almost a necessity, and looking back over the past century and recalling the names of Lamé, St. Venant, of Jamin and Cornu, of

* See Engineering, vol. cv., page 83.

ALIGNMENT TESTER FOR MACHINE TOOLS.

CONSTRUCTED BY THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY, LIMITED, CAMBRIDGE.

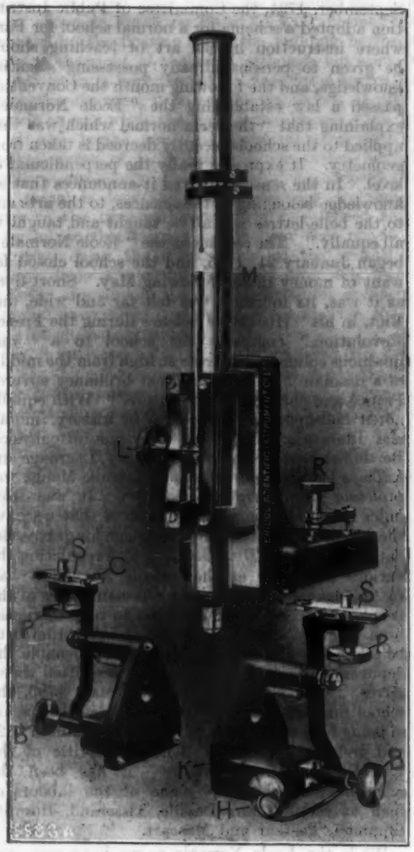


Fig. 1.

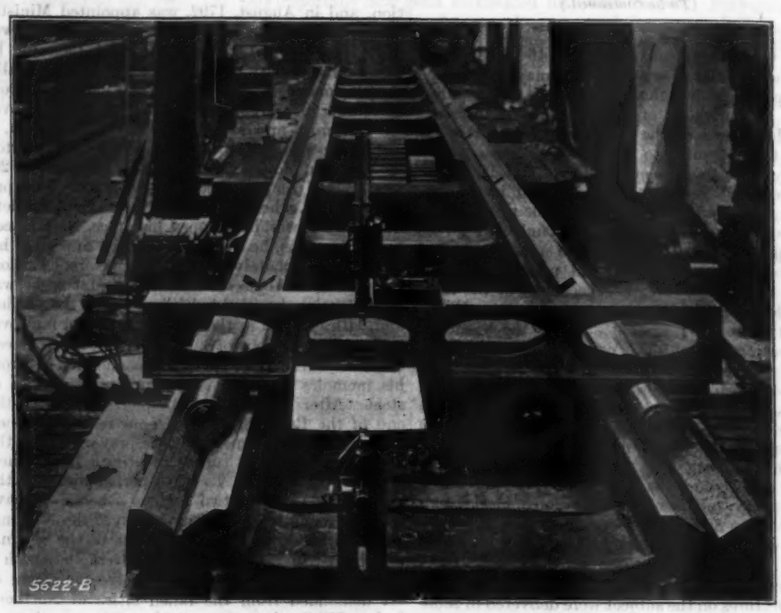


Fig. 2.

Fig.3.

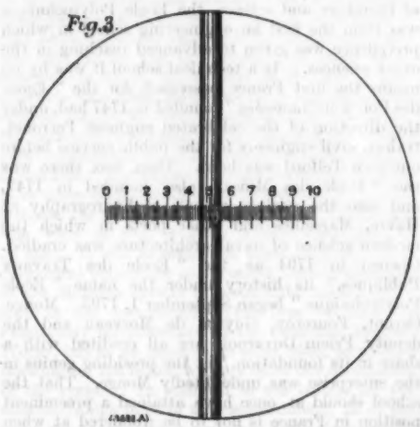


Fig.4.

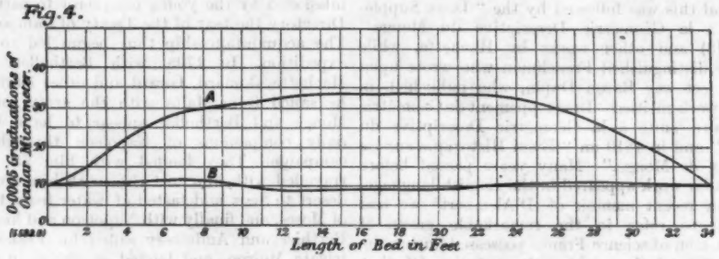
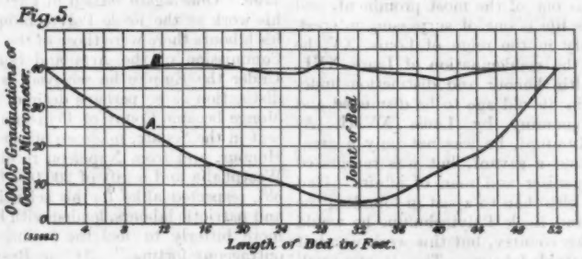


Fig.5.



Becquerel and Poincare, it will be seen that the reputation of the school has not diminished with the passing of years. To-day it stands a splendid monument not only to the undeniable genius of a people second to none in their efforts to unfold the secrets of nature and to apply their discoveries to the well-being of mankind, but also to the enthusiasm, energy and judgment of its founders.

ALIGNMENT-TESTER AND MICROSCOPIC TOOL-SETTER.

We illustrate on the present and opposite pages two useful devices for securing accurate results in workshop practice recently introduced by the Cambridge Scientific Instrument Company, Limited. The first of these is the alignment tester represented in Fig. 1, which provides the means of accurately determining any lack of straightness in the guiding surfaces of planing machines, lathes or similar tools. This is done by comparing the straightness of the surface under test with that of a fine wire stretched horizontally between two small clamps. These clamps C, C, are mounted on brackets K, K, and these brackets are fixed in any way that may be convenient to opposite ends of the machine under test.

The arrangement used in testing the alignment of a planing machine by this device is represented in Fig. 2. Here one of the brackets K is shown in the foreground clamped to a bar which in its turn is bolted to the bed of the tool. The bar supporting the clamp at the other end can also be clearly seen. The brackets K, K, abut on these bars on three feet which can be seen on the back of the left-hand bracket in Fig. 1. The position of the clamp C, and consequently that of the end of the wire, is provided with three adjustments. The arm to which it is secured can both rock and rotate on its pin. The rocking adjustment is effected by means of the screw B, backlash being taken up by the helical spring shown. The screw B has a ball head at its left-hand end, which engages with a slot in a slide, the position of which can be varied by means of the screw H. The arm which carries the clamp is thus swung to right or left, and gives a corresponding small transverse movement to the end of the wire. Finally the level of the latter can be varied slightly by the screw P which abuts as shown on one leg of the spring S.

The position of the wire when stretched is observed through a microscope M, Fig. 1, which is carried on the bracket shown. This bracket has a three-point support, two of the points being fixed studs whilst the third is provided by the screw R. A delicate level is fitted as indicated, and by turning R the telescope can be truly adjusted to the vertical.

In making a test the bracket T is mounted on a suitable rigid fixing, this being provided by the maker of the machine tool to be tested, as its form will vary with the kind of machine to be dealt with. In the case represented in Fig. 2 this carriage takes the form of a cross-bar, which is supported in the guides under test on feet, which in this instance consist of short cylinders of steel. The microscope is located on this carriage by holes drilled to take the two fixed studs at the base of its bracket, and is then levelled as already explained by the screw R.

The stretched wire is adjusted so that at each end of the bed its image crosses the micrometer scale

with which the eyepiece is fitted in the same position. This adjustment is effected by the screws H, Fig. 1, whilst the screws P serve to secure that both ends of the wire are accurately in focus. This adjustment is made two or three times, shifting the position of the saddle from one end of the bed to the other until the accuracy of the setting is definitely established.

A view showing the appearance of the wire and micrometer scale, drawn to two-thirds the size seen through the microscope by the observer, is reproduced in Fig. 3. The scale divisions each represents half a mil. The microscope must be adjusted to be exactly vertical, so that it can be moved up and down in a

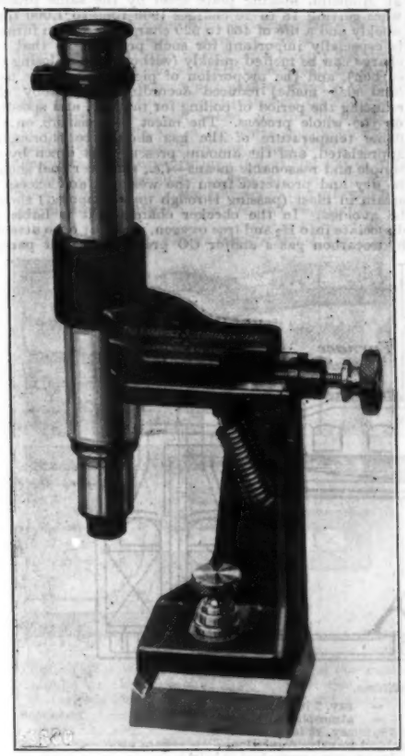
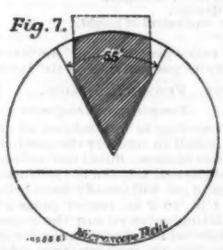


FIG. 6.



FIGS. 6 AND 7. MICROSCOPIC TOOL SETTER.

vertical direction to bring the wire into focus without affecting the readings. The length of the microscope tube must, of course, be kept constant or the value of the divisions of the ocular micrometer would be altered. The sag of the wire does not affect the readings, since the quantity read is the distance between the wire and the tool bed in a horizontal plane. Readings are next taken at intermediate positions of the saddle, and the errors tabulated and finally plotted. Two sets of curves thus obtained are represented in Figs. 4 and 5. The upper curve, A, in Fig. 4 shows the errors found in a 24-ft. planing machine used for planing grinding-machine bodies. As stated, the micrometer reads to half thousands, and it will be seen that the maximum deviation from straightness was 12 mils. The bed was then sprung to correct the bend in it, and the lower curve, B, shows the final result. It was not worth while carrying the correction further than this as the remaining error is less than that arising from the natural distortion of a casting after removal from the planer.

In Fig. 5 the observations made upon the ways of a 52-ft. planing machine are represented. Here the original error, shown by the line A, was about 17 mils, and was reduced to the very low limits shown in the upper curve B, by means of the observations made with the alignment tester. After thus trueing the machine, a portion of a grinder bed, 30 ft. long, and weighing 14 tons, was planed, and the maximum error in this as delivered from the planer was only 2½ mils. This grinding machine had a total length of 54 ft. and the end portions of the bed were each 12 ft. long and were machined with correspondingly small errors. On joining the three sections together the maximum error in the alignment over the whole length of 54 ft. was found to be but 9 mils. By using the alignment tester it was easy to find where the work of correction should be commenced, and one day's work sufficed to reduce the error to 2½ mils. The wheel head of the grinder was next mounted upon the body and the alignment re-tested. The error was found to have increased to 5 mils, and a further correction was made accordingly. The instrument easily shows the deformation that can be produced by the sideways pressure of a finger on the bed of a 5-in. lathe, 6 ft. long.

The second device under notice is that shown in Fig. 6, and is a microscope intended for use in setting the tool in accurate screw cutting. It consists of a compound microscope having an eyepiece, at the focus of which is a diaphragm ruled as in Fig. 7. Through this eyepiece the tool and the diaphragm can be viewed simultaneously. Any error in the setting is clearly visible since the microscope has a magnifying power of 20. It is thus easy to set the tool true within a limit of 3 minutes of arc. The cross-line marked on the diaphragm, as indicated in the lower half of Fig. 4, is set parallel to the work between the centres. The microscope is mounted on the slide rest and moves with it. It is provided both with transverse and longitudinal adjustments as indicated.

INDUSTRIAL NOTES.

MR. DOUGLAS VICKERS, presiding last Tuesday at the fiftieth annual meeting of Vickers, Limited, said that the report which had been issued gave but a bald statement of the service the company had rendered to the country in the year under review, 1915; it should be recollected, however, that they were still precluded from giving details even for that year. But they had inaugurated the policy, since adopted by the Ministry of Munitions, of employing to the fullest extent both their own works, and those of outside engineering firms. The result was an enormous increase in output, which ran into a figure of about 25,500,000*l.*; taking into account interworks deliveries, it was something over 29,000,000*l.*

These figures were not reflected in the profit and loss account, and it might be asked why, with such a huge turnover, the profit and loss account did not show a higher figure. The answer was that the company was so limited by the Munitions of War Act and by the Finance Act that the profit and loss account bore very little relation, indeed, to the profits made in the three pre-war years which went to make the standard period. If they worked it out it would be found that the profits paid out to the shareholders or to the capitalists as interest on their money invested only amounted to about 870,000*l.*; this represented only 3½ per cent. on the smaller turnover, which did not take into account the interworks' deliveries, or 3 per cent. if taken on the major sum. He thought that on such figures they could claim that they were not profiteers, and that these figures were the best answer possible to that section of the Press that abused the capitalist in general terms and the armament companies in particular. To his mind it was a question whether a company like Vickers should not have been entitled to some better treatment. They had spent all the years before the war building up their capabilities for the huge output mentioned, and had at enormous cost made preparations for the eventualities which came in 1914. Since then they had opened their works to competitors, had given designs to competitors in this country and abroad for manufacture, and had received nothing at all in return except, of course, thanks—certainly nothing that could be shown in the profit and loss account. Even if it had involved special legislation he thought such firms as theirs were entitled to some special consideration.

Dealing with the peace preparations, Mr. Douglas Vickers recapitulated the directions in which the company hoped to work. They expected a very largely increased output in ships, railway material, motor cars, engines, turbines and electrical material, and among new products, of magnetos, large gas engine, land boilers, wood products, sewing machines and repetition work generally. To carry on such a largely increased volume of trade they would, of course, require more raw material and more stocks of finished material, more particularly the latter, because of the changed nature of the trade. If the Government ordered a gun the company started about making it, but people who bought sewing machines did not want to give their order and await delivery while it was being made. It was necessary to have large stocks of such products in their own and agents' warehouses. That, of course, in turn demanded a very large amount of capital sunk in the work. There were other things to be taken into account. In future they would have to go much farther afield in their search for work in the nature of electrical and railway material and many other things, and they would then be brought into conditions of payment which were different from what they had been accustomed to in this country. They would probably have to do a great deal more financing, and it was possible they might have to join with banks in financing undertakings. In respect to that, of course, they would expect returns not only from the articles supplied, but for the money advanced. The Germans in the past had made a great deal of that form of trade, and it was hoped that the field would not be left to them alone in the future.

At the close of his speech, Mr. Douglas Vickers stated that everything promised well for the manufacturer and the trader, provided their relations with labour remained good. One's anticipations in regard to that, he thought, were largely coloured by one's own temperament. He was not gloomy, and therefore viewed the future without fear. The lessons of the war had been learned by a good many people besides themselves, and he hoped, therefore, for very much better relations with labour in the future. The quarrels during the war had rarely been between the employers and their workmen, but had been brought about by outside circumstances. He believed the employers and workmen had learned to understand each other better. The great difficulty in the past had been that the employer had not put his views before the workmen, but had allowed the men to be influenced by the street corner agitator, who took the view that the employer was necessarily the enemy of the wage earner. The Vickers company were trying to take their part in the campaign that it was hoped would remedy that, and they had accordingly joined the alliance of employers and employed; they were also supporting the Federation of British Industries, which aimed at putting forward before the authorities the united views of the employers as a class, which in the past had been too much ignored, more particularly in regard to general legislation.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour:—

Edge Tool Trade and Saw Trade.—The various classes of workmen concerned are to be paid from August 10, 1918, an advance in the case of men aged 21 years and over, of 4*s.* a week, in the case of men between 18 and 21 years of age of 3*s.* 6*d.* a week, and in the case of youths 1*s.* 9*d.* a week. The men 21 and over have previously received a flat rate advance in lieu of the bonus of 12½ per cent. and 7½ per cent. on earnings, and the committee had regard to this fact in awarding such men the advance of 4*s.* a week. The above-mentioned advances do not apply to machine-knife grinders; they are to receive an advance (in addition to 40 per cent. previously granted) of 7½ per cent. on their pre-war piece prices from first pay after November 10, 1918.

Ship-repairing Trade, Hull.—From first full pay after May 20, 1918, riveters engaged on ship repairs in the Hull district are to receive on advance over pre-war piece prices, of 35 per cent. (plus 2½ per cent. for holders-up). This advance to include all increases since the outbreak of war with the exception of 10 per cent. given in April, 1915, and war advances of 16*s.* 6*d.* a week given under previous awards.

Ship-repairing Trade, Grimsby.—When engaged on ship-repairing work (merchant and Admiralty) platers and angle-iron smiths are to be paid a further advance of 10 per cent. on gross prices; the current piece rates of caulkers and riveters are to be increased by 20 per cent. and 35 per cent. respectively; all previous additions to merge in these advances with the exception of the 10 per cent. given in April, 1915, the special war advances of 16*s.* 6*d.* a week given under previous awards and the 7½ per cent. bonus on earnings. Workers employed on lieu rates are to receive an advance of 20 per cent. In all cases payment to be retrospective from first pay after June 27, 1918.

The joint secretaries to the Midland Iron and Steel Wages Board have published the report of the accountants for the two months ended July and August, 1918, and announce that the wages for puddling during the months of October and November, 1918, will be 19*s.* 3*d.* per ton, and all other forge and mill wages will be advanced 2½ per cent. The 19*s.* 3*d.* is made up of 18*s.* 3*d.* per ton in accordance with the sliding scale, and 1*s.* per ton on puddling, or 10 per cent. on all other forge and mill wages as the equivalent of subsidies on pig-iron. These wages took effect from Monday last, and will continue until Saturday, December 7. In addition to the puddling rate of

19*s.* 3*d.* per ton there will be 6*d.* per ton bonus given to the puddlers by resolution of the Wages Board which met on July 15, 1912. This applies to puddlers only, and will make the total puddling rate 19*s.* 9*d.* per ton. Instructions will be duly issued as to merging where it applies, after result of negotiations now proceeding with the Ministry.

The accountants have examined the returns of the sales of iron made by the 17 selected firms for the months of July and August, 1918, and certify the average net selling price to have been 16*l.* 1*s.* 1.63*d.* per ton, as against 15*l.* 15*s.* 2.30*d.* for the previous two months.

The adjustment of war's conflicting demands for men and material is one of the most difficult of the problems presented to the Government's Labour Departments, because changing conditions naturally affect the incidence of the demand. Thus the Schedule of Protected Occupations drawn up so recently as last February for men employed on Admiralty, War Office, or munitions work, or in railway workshops, has already been affected, as regards wood-workers, by the comparatively less urgent demand for those engaged on certain classes of munitions, and the increased demand for men for building and constructional work. Another factor which is compelling is the ever-growing demand for wood-workers in the Royal Air Force. In the February Schedule, woodworkers engaged in the production of aeroplanes and other munitions were protected from military service at varying ages, whilst wood-workers engaged on building work were not included, but were dealt with as regards recruitment under special administrative arrangements. It has been felt that these varying systems of protection tended to operate harshly on men of similar qualifications. In these circumstances, the Government have decided to issue a supplementary schedule in which men employed in the building trades on approved work for Government Departments, will be included by the grant of protection certificates according to certain age limits. The protection of all wood-workers, whether on building work or munitions, will be equalised by the fixing of a "flat" age limit of protection of 29 for grade 1 men, and 24 for grade 2. A committee has been formed by the Ministry of National Service for the purpose of certifying what building and constructional work comes within the scope of the new schedule. The schedule has been discussed by the Ministries of National Service, Munitions and Labour, with the trade unions concerned. It is a notable fact, marking a new departure in industrial affairs, that the building trades were represented in these negotiations for the first time, by their National Industrial Council established under the scheme outlined in the Whitley Report. It should be noted that, apart from the men referred to above, the February schedule remains unaltered.

The sub-committee appointed by the joint meeting of the Scottish Millmen's Association and the Iron and Steel Trades' Confederation have held a meeting for drafting a scheme for the formation of a Whitley Council for the trades named. They have now decided to approach the employers' associations with a view to the sub-committee laying before them the proposals for the establishment of Works' Committees, District Councils, and a National Council. Under the draft scheme it is proposed to divide the country into eight divisions—two for Wales, one for Scotland, and five for England. The District Councils, it is suggested, should deal with local matters, but the National Council would deal with wider issues, such as exports and imports. Further meetings are to be held when the employers have discussed the matter with the workmen's representatives.

The average net selling price (including subsidy) of No. 3 Cleveland pig iron for the third quarter, from July to September, has been certified at 118*s.* 10.88*d.* per ton, as compared with 107*s.* 10.68*d.* per ton for the second quarter of the year. There has thus been an advance in price of 11*s.* 0.18*d.* per ton, which means an advance in the blast-furnacemen's wages on the North-east Coast of 13.75 per cent., raising wages from 94.75 per cent. above the standard, to 108.50 per cent. above the standard.

Cutting Lubricants.—A memorandum on cutting lubricants and cooling liquids and on skin diseases produced by lubricants has been issued by the Department of Scientific and Industrial Research. It embodies much information which should be of service to manufacturing engineers. Although no claim for novelty is made, it is believed that many users of cutting lubricants may find in the pamphlet some valuable hints. Mr. T. C. Thomsen is responsible for the text dealing with the technical aspect of the matter, whilst Dr. J. C. Bridge has prepared the section on the medical questions involved. This pamphlet (Bulletin No. 2) is published by H.M. Stationery Office.

THE PRINCIPLES OF OPEN-HEARTH FURNACE DESIGN.*

By Charles H. F. Bagley, Stockton-on-Tees.

In view of the keen interest now being taken in the subject of open-hearth furnace work and design, with the object of raising British practice up to or above the standards of Continental and American practice, the author has thought it opportune to submit a paper in which the subject can be more fully discussed than was possible in the form of reply to the recent Circular Questionnaire issued by the special Committee of the Iron and Steel Institute. The subject may conveniently be resolved into two distinct branches, viz., Metallurgy and Design, the former being chiefly concerned with obtaining the best results from a given furnace, and the latter with a best design for a new furnace (or improvements in existing furnaces). In both directions there seems to be room for some improvement in British practice as a whole. In this paper he endeavours to discuss the subject of design, both from the scientific and the practical points of view, in the light of some fifteen years' varied experience in England, Germany and the United States. For the sake of brevity, opinions are definitely expressed, but he hopes it will be understood throughout that they are but the expression of personal views.

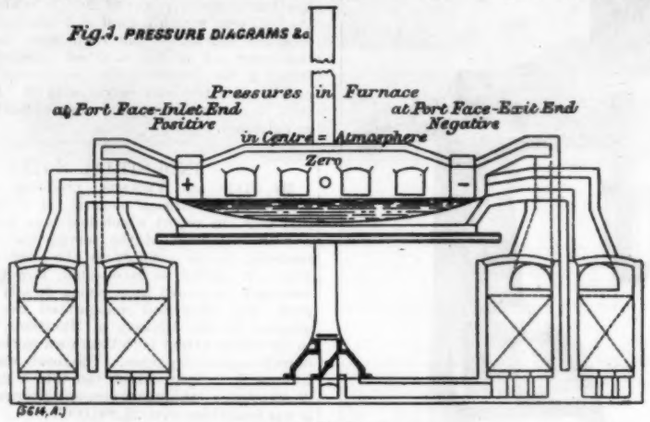
General Requirements.

In order to melt steel at all, the first requirement is an exceedingly high temperature, and it can almost be said that it is hardly possible to attain too high a flame temperature, provided the flame is under control and not allowed to impinge direct on the brickwork. As in the blast furnace, so in the steel furnace, output and efficiency are functions of the average temperature attainable, rather than of the heat units generated; for temperature is the factor which determines the efficiency of utilisation of such heat units. The chief object of regenerating gas and air is thus not so much the recovery and return to the hearth of a proportion of the waste heat units, but rather to enable a higher flame temperature to be reached, by means of highly superheating both gas and air before bringing them into contact. It is important, therefore, that the highest possible temperatures should be reached in the checker chambers, so that they may be realised in both gas and air on reversing; and also that the checker work should be deep enough to allow a high average temperature to be maintained throughout each reversal. Consideration of the subject of theoretical flame temperatures shows that to realise the maximum it is important to provide not only a rich gas, but a dry gas and air (very important points, but outside the subject of furnace design), together with the minimum excess of air for complete combustion, and the maximum initial temperature, on each. It is important that the initial temperatures of gas and air should be approximately equal throughout; for the fact of one being higher than the other rather implies that the other is less than it might have been, and the resulting flame temperature correspondingly lower. In designing the furnace, these points should always be taken into account; and the heating surface, and supply of heat to gas and air chambers respectively, should be arranged accordingly.

Though these points may appear to be minor matters, it should be remembered that their effect is cumulative, for a higher flame temperature results in a shorter, but more intense flame, which allows more gas to be carried, with a greater development of heat in the furnace and a higher temperature of outgoing gases, and this, in turn, results in hotter checkers and a higher temperature of gas and air on reversal, and further increase of flame temperature, &c., till the furnace becomes considerably hotter—and the most effective way of keeping the heat down is by frequent charging and tapping. The author worked for some months on such a furnace in Germany in 1904—carrying out the so-called "Martin process"—with 75 per cent. of scrap, for spring, tyre and axle steels, and tapping 12-ton heats every 4½ hours as regularly as clockwork, and all hand-charged, too.

The average make was 36 heats (436 tons) per week (start charging Sunday 9 p.m.—last tap before Sunday 6 a.m.—12-hour shifts—average life 390·6 charges—repairs cost 2·03*s.* (bricks and labour)—wages cost 3·80*s.*—coal consumption 25·54 per cent.—ingot yield 95·34 per cent.); while some new 50-ton furnaces, machine-charged, at the neighbouring works of Thyssen, at Mülheim, making plate steel by the same process, were getting 18 to 20 charges (900 tons to 1,000 tons) weekly and a life of 460 to 520 charges. A keen furnace is especially important for such practice, so that the charge can be melted quickly (without risk of losing the carbon), and the proportion of pig-iron and lime used (and slag made) reduced accordingly; thereby also reducing the period of boiling for tapping, and speeding up the whole process. The effect of moisture on the flame temperature of the gas should be thoroughly appreciated, and the amount present kept down by all simple and reasonable means—i.e., producer coal should be dry and protected from the weather, and excess of steam in blast (passing through undecomposed) should be avoided. In the checker chambers it is liable to dissociate into H_2 and free oxygen, which at once attacks hydrocarbon gases and/or CO present, so that partial combustion takes place in the chambers at the expense of the quality of gas arriving at the furnace.

Fig. 1. PRESSURE DIAGRAMS &c.



Supply Conditions.

	Gas pressure in main	= say, 2 in. w.g.
	Air pressure at valve	= atmosphere.
	Draught at chimney base	= say, 1½ in.
Gas Pressure	in flues	= supply pressure, subject to valve regulation.
	at port	= supply pressure, plus pressure, equivalent of height.
Air Pressure	in flues	= atmosphere, subject to valve regulation.
	at ports	= atmosphere, plus pressure, equivalent of height.
Suction ..	in flues	= chimney draught, subject to damper.
	at ports	= chimney draught, less pressure, equivalent of height.

Open-Hearth Furnace Design. (*Pressure and Temperature Diagrams.*)

Before proceeding to the subject of combustion and volumes, it is well to consider the conditions of pressure existing in the furnace, flues, and valves, &c., and the forces behind gas and air, and in the chimney.

The incoming gas will usually have behind it an initial pressure of 1 in. to 2 in. (water gauge), but is reduced by the regulating valve to suit the requirements of the furnace; while behind the incoming air there is only the difference in density between two columns of air of atmospheric and regenerated temperatures respectively, and of height equal to that between the bottom of the checker chambers and the level of the air port. The effective height of the chimney should be measured from the level of the ports, and its pull considered as being exerted at the face of the ports. The pressure in the body of the furnace must necessarily be atmospheric and approximately balanced; for the velocity of gases under the slightest suction—or pressure—is such that if not, there must be an enormous inrush of cold air or an equally large outburst of flame at every door and crevice. The incoming gas and air must, therefore, be considered as being delivered under slight pressure through large orifices into an open space, combustion taking place under constant (atmospheric) pressure, and the flame and waste gases travelling freely down the furnace until they come within the influence of the chimney draught near the face of the ports. Thereafter the waste gases are under a slight negative pressure, and will expand in volume accordingly; but throughout the differences in pressure vary so slightly (rarely more than 5 mm. Hg., or 0·66 per cent.) from the atmosphere, that their effect on volumes is almost negligible, and especially so when compared with the variations due to differences of temperature at various points in the circuit.

Thus all questions of areas are mainly dependent on temperatures rather than on pressures at different positions.

The diagram, Fig. 1, clearly illustrates the points.

It should always be remembered that the amount

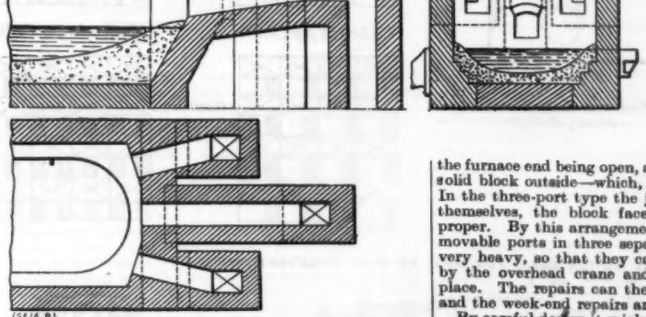
* Paper read before the Iron and Steel Institute on Friday, September 13, 1918.

of gas admitted to the furnace is, and must be, regulated at the inlet valve to suit the requirements of the furnace; and the air should be regulated to suit the gas supply. In practice, however, the usual difficulty is to get sufficient air supply to consume the gas available, the gas being under a positive pressure. Hence the prevailing custom is to open the air valve to its full and to regulate solely on the gas valve. Deep checkers are, therefore, necessary not only for high initial temperatures, but also to ensure an ample supply of hot air to the furnace, without which full use cannot be made of the gas available. The chimney height should be increased accordingly.

The actual pressure at different points can hardly be foretold under such conditions; but it is often useful to have a pressure diagram—taken when the furnace is in good condition and working well—as a basis for comparison with conditions prevailing towards the end of its life. Without a standard for comparison, such diagrams are of little value; and the author prefers a diagram of temperatures at the corresponding positions—always taken, of course, at the same stage of the process (say, just before tapping and just after reversing).

Pressures should be taken on the incoming end: (1) At the valves or in the flues before entering the checker chambers; (2) in the slag pockets or checker chambers after regeneration; (3) at the top of uptakes (virtually in the ports); and at the corresponding positions on the outgoing end—care being taken to note the difference between positive and negative pressures.

Fig. 2A. TYPE I.-3 PORT DESIGN WITH AIR COOLING.



(5614. B)

The initial pressure in the gas main, and the maximum draught at the chimney base, should also be noted; the furnace should then be reversed and the readings repeated.

With the temperature diagrams there is no question of positive and negative results. The readings should be taken in the same positions, but care should be taken that the furnace conditions are the same, and that the furnace has been working the same length of time on each end. The relative volume of air, gas and waste products passing at any point is mainly affected by their temperature variations (which are considerable), rather than by their pressure variations (which are comparatively small), and their velocities are proportional to the volume passing divided by the sectional area at that point, subject, of course, to frictional losses. Given their initial volumes and temperatures, and the subsequent temperatures at different positions, it is possible to calculate the areas so that the velocities will be approximately constant throughout. The volumes entering are, however, subject to control at the inlet valves, and the volumes delivered into the combustion chamber are limited by the area of the discharging orifices (or ports). Between these two points, sectional areas may be anything desired, provided not less than the ports, and may, therefore, be determined by other considerations. So also as regards the outgoing end—the flow of waste gases is subject to control by damper in the chimney flues, and to the inlet area at the ports; and the sectional area at any point between may be anything desired, provided not so small as to check the even flow between these two points. The gas and air port areas (and chimney flue areas) must be taken together as regards the total volume of waste gases to be passed; but the question of proportions to be taken by each will be determined by other considerations. It may be noted here that when these proportions are decided, they can be permanently and automatically secured—without the aid of dampers on every chimney flue (which would be extremely difficult to regulate accurately)—by simply proportioning the chimney flues, behind the valves, to the volumes of waste gases it is desired to draw through gas and air chambers respectively. The author has always considered this one of the most important and least considered points in the whole design. The usual practice is to "make them big enough," regardless of relative volumes or other reason—with various results in the checker work and on the initial temperature of gas and air—all resulting in loss of flame temperature and efficiency of furnace.

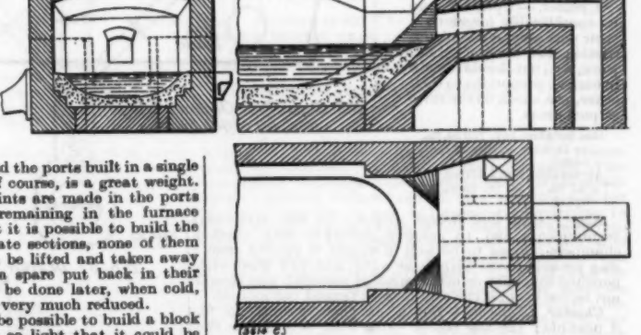
FURNACE DETAILS. (*Port Ends.*)

The respective merits of different types of port ends are much disputed questions, particularly as between the two standard types, (1) the solid block with two air ports, Fig. 2A, and (2) the open block with a single overhead air port, Fig. 2B; and it seems to remain purely a matter of opinion and of correct detail, to the absence of which so many failures are attributable. Type (2) is generally regarded as the keener and faster working design, and allows a short length of combustion space before the hearth proper is reached, and, of course, removes the block so much further back on the outgoing end, thus reducing the chance of "burning" it. On the other hand, it is the weaker structure and requires more careful designing or the gas port is liable to lose its shape and throw the live gas on to the linings. Its natural tendency is to spread the flame and keep it down (whereas the opposite is the case with the three-port type), and a wider furnace is desirable for this type. The three-port type, though slower working and allowing no preliminary combustion space, is said to stand up better, though it has to stand the direct heat of the outgoing gases, and is liable to get "burnt" unless the gas supply is closely regulated. No great care is needed in design or building; there is less chance of burning the side walls (though more of the roof), and there is no brickwork subject to heat on both sides without cooling surface, as in the case of the arch between gas and air ports in type (2). On the whole, there seems little to choose, though personally the author prefers the keener furnace. These remarks apply equally to tilting furnaces, but the necessity of movable port ends rather complicates the matter. In type (2) the joint between furnace and port ends is made at the face of the block, the furnace end being open, and the ports built in a single solid block outside—which, of course, is a great weight. In the three-port type the joints are made in the ports themselves, the block face remaining in the furnace proper. By this arrangement it is possible to build the movable ports in three separate sections, none of them very heavy, so that they can be lifted and taken away by the overhead crane and a spare put back in their place. The repairs can then be done later, when cold, and the week-end repairs are very much reduced.

By careful design it might be possible to build a block of type (2) in a single piece so light that it could be handled and changed by the overhead crane as the individual ports of type (1) are—which would greatly simplify matters and yield the advantages of both.

One of the advantages of a tilting-furnace is the facility of getting at the ports for repairs at the week-end.

Fig. 2B. TYPE II.-OVERHEAD AIR PORT DESIGN WITH AIR COOLING.



(5614. C.)

COMBUSTION OF PRODUCER GAS.

The combustion of 100 M³, assumed dry and neglecting tarry vapours, of analysis as under and at 0 deg. C. by 760 mm. pressure, is as follows:—

By Volume.	Per Cent.		Kg.		Kg.		By Weight. Kg.
H_2	8·0	=	0·72 requires oxygen		5·6 to form		6·3 H_2O
CH_4	5·0	=	3·60	,, ,,	7·2	,,	8·1 H_2O
					7·2	,,	9·9 CO_2
CO	25·0	=	31·50	,, ,,	17·9	,,	49·4 CO_2
CO_2	5·0	=	9·90	,, ,,	—	,,	9·9 CO_2
N_2	57·0	=	72·00	,, ,,	—	,,	72·0 N_2
	100·0		116·70	,, ,,	37·9		155·6 products.

To this 37·9 kg. oxygen may be added some 25 per cent. excess to ensure complete combustion, bringing up the total oxygen required to 47·4 kg. This represents 205 kg. of air—introducing 157·6 kg. of nitrogen—which, together with the excess oxygen, must be added to the products as above, making the result as under:—

	By Weight.	Per Cent.	By Volume.	Per Cent.
CO_2	69·2 kg. =	21·5 or	35·0 M³ =	14·5
H_2O	14·4 kg. =	4·5 or	17·8 M³ =	7·4
N_2	229·6 kg. =	71·1 or	182·2 M³ =	75·4
O_2	9·5 kg. =	2·9 or	6·6 M³ =	2·7
Total	332·7 kg. =	100·0 or	241·6 M³ =	100·0

Thus 100 M³ gas (= 116·7 kg.) requires 159 M³ air (= 205 kg.) to form 242 M³ (= 323 kg.) of products—all volumes under standard conditions (0 deg. C. by 760 mm.).

In practice the conditions are different, and may be assumed approximately as under:—

	Deg. C.	Mm.
Air—At inlet valve	15	by 760
After regeneration	1,250	by 760
Gas—At inlet valve	800	by 765
After regeneration	1,250	by 765
Waste Products—At port face, say ..	1,500	by 750
In chimney flues ..	600	by 755

100 M³ *of Gas* (0 deg. C. by 760 mm.) then becomes—
208 M³ entering at valve.
555 M³ entering through gas port.

159 M³ *of Air* (0 deg. C. by 760 mm.) then becomes—
168 M³ entering at valve.
887 M³ entering through air port.

242 M³ *Waste Products* then becomes—
1570 M³ going out through ports.
778 M³ passing through chimney flues.

N.B.—It is interesting to note the total volumes entering and leaving the combustion chamber through the ports, viz., 1,442 M³ entering and 1,570 M³ passing out.

Ratio of Air to Gas Passages.—So far as supply to the furnace is concerned, and subject to regulation by the valves, the intake areas, flues, &c., may be in the ratio of 168/208, or 0·80 air to 1 of gas, and the checker chambers, uptakes and ports, in the ratio of 887/555, or 1·60 air to 1 of gas.

It is, however, more important to arrange for the proper distribution of heat between the checker chambers in such proportion as to maintain an equal temperature on both gas and air when the furnace is reversed. This is dependent on the amount of heat to be imparted to gas and air respectively—which thus takes account of their initial temperatures and relative weights—neglecting differences in specific heats. These weights were found to be 116·7 kg. of gas, entering at initial temperatures of 300 deg. and 15 deg. C. respectively; and both are to be raised to 1,250 deg. C. by the regenerators. The heat units absorbed in so doing will therefore be in the ratio of 205 (1250—15) = 254,000 by air, to 116·7 (1250—300) = 110,800 by gas, *i.e.*, in the ratio of 2·30 by air to 1 by gas, and the volumes of waste gases passed through air and gas chambers respectively should be in the like ratio—2·30 to 1.

To effect this distribution with the same chimney draught in the flues and at the face of either port, the areas of air to gas passages, ports and flues, must be in the same proportion (see Fig. 3), which differs considerably from that required for the incoming gas and air. There are thus two conflicting conditions as regards ratio of port and flue areas, of which the proper distribution of the waste heat is more important; for the incoming volumes can be controlled at the valves. Areas should be fixed accordingly, and the proportion maintained throughout to ensure the even flow of waste gases throughout. The author considers it important to aim at an even flow of gases, and to avoid abrupt changes of velocity as far as possible. It was previously pointed out that sectional areas between ports and flues may be anything desired; but the only place where he considers it desirable to alter this proportion is in the width of the checker chambers, by manipulation of the checker work, where the ratio may be halved to advantage as regards the general design of the furnace, without affecting the balance in any other way. Variations from the data and assumptions, gas analysis, excess of air, moisture, temperatures and pressures, &c., will affect this ratio to some extent, but it will usually remain between 2 and 2·50 to 1.

N.B.—The gases arising from the oxidation of carbon in the charge have not been taken into account, as they will rarely exceed 1 per cent. of the total volume of waste gases passing out at, say, 1,500 deg. C. The effect of poor gas is to decrease the ratio of air to gas passages, that of richer gas or excess air, to increase it.

OPEN-HEARTH FURNACE DESIGN.

In designing an actual furnace there are two leading dimensions required as a basis, viz., gas-port area and hearth area per ton of steel capacity, from which the rest may then be calculated. These data are best taken from practical experience with successful furnaces, but with due regard to other working conditions; for practice and circumstances are very variable in both respects.

Hearth Area.—In this country a hearth area of 5 sq. ft. to 6 sq. ft. per ton is usually allowed for acid furnaces, and 6 sq. ft. to 8 sq. ft. per ton for basic (fixed) furnaces. Continental and American furnaces often have a larger allowance than this and a shallower bath accordingly (especially in the case of the smaller furnaces) and would be made to hold a larger charge, and rated at a higher capacity in this country. Which is the better practice is purely a matter of opinion, largely influenced at home by the factor of wages rates. In any case, the author prefers the English practice of charging as much as the furnace can comfortably hold, if the maximum output is required, but the point should not be overlooked in making comparisons with lower-rated foreign furnaces. Large tilting furnaces, working the Talbot process, &c., are, of course, much deeper than fixed furnaces of

otherwise similar dimensions, and may hold nearly double the weight of steel accordingly, so that output comparisons on the basis of nominal capacities are altogether misleading, independent of differences in the practice followed and raw materials employed. The only proper basis of comparison of different furnaces on similar practice seems to be their respective outputs per unit of hearth area.

Gas-Port Area.—Practice in this respect is very variable, but an allowance of 4 sq. in. per ton for acid furnaces and 5 sq. in. for basic furnaces is usually satisfactory. This factor is really proportional to the hearth area, independent of its depth, and is preferably stated in square inches per unit of hearth area—*i.e.*, for acid and basic fixed furnaces, 0·70 in. to 0·80 in. per square foot of hearth. Personally the author prefers larger areas both for gas and air ports—subject to proper control at valves—and, of course, in due proportion to each other.

For a fixed 100-ton basic open-hearth furnace, on these lines (see Fig. 5), the leading dimensions are :—

Hearth.—At 7 sq. ft. per ton = 700 sq. ft. = 50 ft. × 14 ft. = 46 ft. 8 in. × 15 ft., or equal.

Gas Ports.—At 0·80 sq. in. per foot hearth = 560 sq. in. = 24 in. × 24 in., or equal.

Air Ports.—At 2·25 times gas ports = 1,260 sq. in. = 1 overhead type 10 ft. 6 in. × 0 in. to 15 in.; or 2 ordinary ports 25 in. × 25 in. each, or equal.

Uptakes.—Uptakes may be considerably larger than their port areas, to minimise friction and wear of brickwork, &c., but should remain in correct proportion to each other, as a check on the ratio of port areas.

Gas uptakes, say, 720 sq. in. = 24 in. × 30 in. each, or equal.
Air uptakes, say, 1,620 sq. in. = 27 in. × 30 in. each, or equal.

Slag Pockets and Bridge Arches.—To suit structural requirements and to connect smoothly with checker chambers; areas to be well in excess of uptake areas; slag pockets faced with false walls, and half filled with perished dolomite or other suitable material, and should not be too deep, if the slag is to be tapped out molten.

Checker Chambers.—Depth of checkerwork, 15 ft. if possible; the top course to be 2 ft. or so below the bridge for protection and for even diffusion of gases. To provide ample heating surface and reduce the velocity and friction of gases, and to allow for gradual "silting up," the horizontal area of the open spaces should be at least eight or ten times the port areas, and in proportion as before. The length of gas and air chambers being equal, their widths will be in the like proportion (1 to 2·25), which, however, makes rather an awkward design, and I therefore prefer to employ different types of checker work in the two chambers and to adjust their relative widths accordingly. This may be done by using 6 in. by 6 in. open flue type checkerwork in the air chambers, and 6 in. by 3 in. open flue or 6 in. by 6 in. single checked brickwork in the gas (Fig. 4); the width of the gas chamber being doubled to keep the total passage areas in proportion. In the 6 in. by 6 in. open flue type—plan view—the open spaces are four-ninths, and the bricks five-ninths of the total area; whereas in the 6 in. by 3 in. open flue or 6 in. by 6 in. single checked types the spaces amount to only two-ninths and the bricks to seven-ninths of the total area.

The gas-port area was taken at 560 sq. in. and the air port at 1,260 sq. in., which, multiplied by 8, gives 31·1 sq. ft. and 70 sq. ft. of spaces required in gas and air checkerwork respectively. The gas chamber area will therefore be :—

For 6 in. × 6 in. checker work, $\frac{4}{9} \times 31{\cdot}1 = 70$ sq. ft. = 14 ft. long × 5 ft. wide, or equal.
For 6 in. × 3 in. checker work, $\frac{2}{3} \times 31{\cdot}1 = 140$ sq. ft. = 14 ft. long × 10 ft. wide, or equal.

and the air-chamber area (with 6-in. by 6-in. checkerwork) :—

$\frac{4}{9} \times 70 = 158$ sq. ft. = 14 ft. long × 11 ft. 3 in. wide, or equal.

The thickness of any false facing walls or solid partitions to be added to above sizes.

It is possible, though unusual, for the checker chambers to be too large, and the author has known furnaces which would not work properly until their chambers had been reduced in length by nearly half.

Chimney Flues.—As already noted, it is important that the proportion between gas and air flues should be observed. As regards area, the temperature of waste gases in the flues being reduced to 600 deg. C. (or under), their total volume will be reduced to two-fifths (or less) of that passing through the ports; and the flue areas could be reduced accordingly, with allowance for deposit and accumulation of flue dust, and for air leakages, &c. But they may well be made several times larger than this, and are preferably designed to correspond approximately with the chimney area in order to avoid sudden change of velocity. It is quite unnecessary, and probably undesirable, to make them too large, the result being simply to reduce the effectiveness of the ratio of air to gas areas. There is obviously no need to make the flue areas any larger than the port areas—in the present case 560 sq. in. and 1,260 sq. in. respectively, and together 1,820 sq. in.

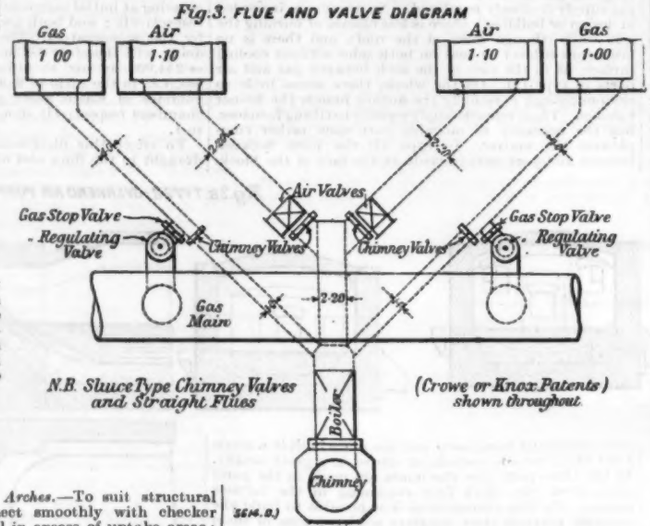
The point is also of interest in connection with dimensions collecting flues below the checkerwork and the height and thickness of bearer walls, which are frequently built needlessly tall and thin and excessively weak for the weight they have to carry—and also in connection with plans for waste-heat boiler, &c.

On this basis, the flues being equal in depth, their respective widths will be in ratio of 2·25 to 1, Fig. 3, and the dimensions will be approximately :—

For gas flue, 560 sq. in. = 2 ft. deep × 23 in. wide,
For air flue, 1,260 sq. in. = 2 ft. deep × 52 in. wide,
Plus 12 in. to 18 in. allowance in depth.

for flue dust accumulation, which brings their combined area reasonably near that of a 5 ft. diameter chimney.

Fig. 3. FLUE AND VALVE DIAGRAM



Chimney Valves should, of course, correspond to flue areas, and must be large enough to avoid any influence on the proportioning of the flues.

N.B.—With the same gas and only 10 per cent. excess air, the ratio comes down to 2 to 1.

Waste-Heat Boilers.

It is often considered a mistake to place boilers in the chimney flues of regenerative furnaces, on the ground that if regeneration is reasonably efficient there should be no material waste heat available, but the consumption of coal by a large open-hearth furnace—approximately 300 tons per 1,000 tons of ingots made—is sufficient to yield a great deal of steam, even on a very low evaporative basis, and there usually is a very material surplus heat in the gases passing up the chimney during at least some stages of the melt, if not during the later half of every reversal period. The lower strata of checkerwork may at times be cooled down to a black heat by the cold incoming air, but in the gas chamber they can never fall below the temperature of the incoming gas—so that the outgoing gases can never be cooled down on reversal to that temperature. The boiler's opportunity does, of course, depend on the thermal efficiency, or otherwise,

Fig. 4. CHECKER WORK

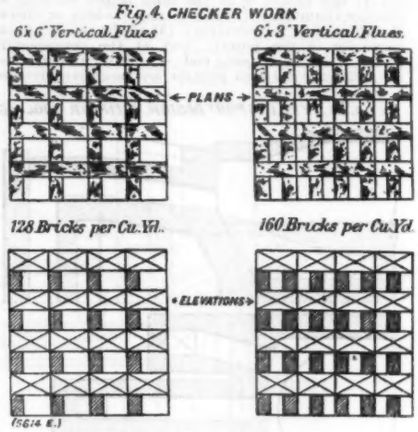
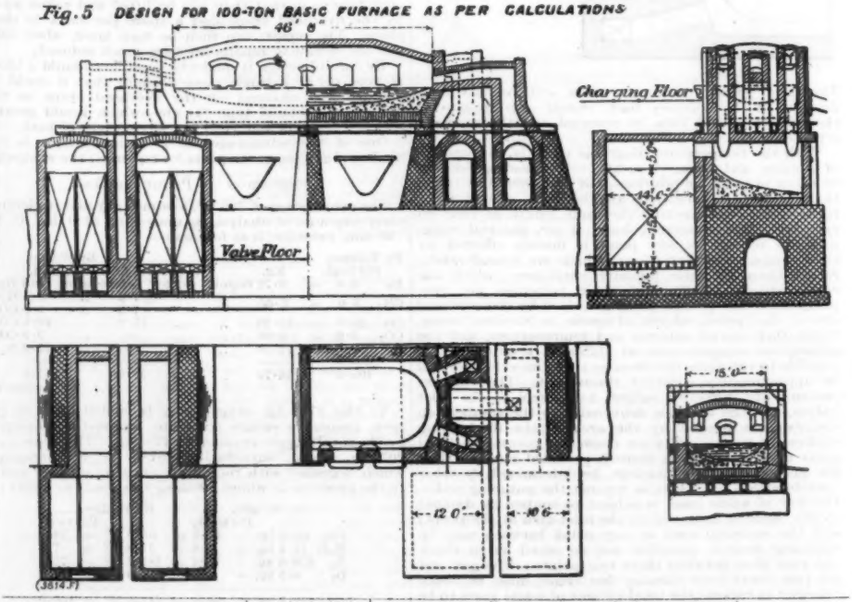


Fig. 5 DESIGN FOR 100-TON BASIC FURNACE AS PER CALCULATIONS



Capacity	20 Tons.	40 Tons.	60 Tons.	80 Tons.	100 Tons.
Hearth area at 7 sq. ft.-ton	140 sq. ft.	280 sq. ft.	420 sq. ft.	560 sq. ft.	700 sq. ft.
Equivalent dimensions, say	17′ 6″ × 8′	28′ × 10′	35′ × 12′	40′ × 14′	50′ × 14′
Gas-port area at 80 sq. in.	112 sq. in.	224 sq. in.	336 sq. in.	448 sq. in.	560 sq. in.
Equivalent dimensions	10″ × 11″	15″ × 15″	18″ × 18¾″	22″ × 20½″	24″ × 23″
Air-port area at 2·25 gas	252 sq. in.	504 sq. in.	576 sq. in.	1,008 sq. in.	1,260 sq. in.
Equivalent dimensions	2 (10″ × 12¼″)	2 (15″ × 16½″)	2 (18″ × 21″)	2 (22″ × 23″)	2 (24″ × 26″)
Gas-checker chamber (6″ × 3″)	28 sq. ft.	56 sq. ft.	84 sq. ft.	112 sq. ft.	140 sq. ft.
Equivalent dimensions	4′ × 7′	7′ × 8′	7′ × 12′	9′ × 12′ 6″	10′ × 14′
Air-checker chambers (6″ × 6″)	31½ sq. ft.	63 sq. ft.	94½ sq. ft.	126 sq. ft.	157½ sq. ft.
Equivalent dimensions	4′ 6″ × 7′	7′ 10″ × 8′	7′ 10″ × 12′	10′ × 12′ 6″	11′ 3″ × 14′
Chimney flues, gas (12″)	11″ × 22″	15″ × 27″	18″ × 30″	22″ × 33″	24″ × 36″
Chimney flues, air (12″)	25″ × 22″	34″ × 27″	40″ × 30″	50″ × 33″	54″ × 36″
Equivalent Chimney diameter	33″	41″	48″	54″	59″

N.B.—Actual chimney diameters should be calculated by the ordinary rules and will usually be larger than as given above; but these diameters should suffice if the height is correct.

The table annexed gives the leading dimensions for furnaces of various sizes from the above data and on the same lines.

of the regenerators and the length of the flues between them and the chimney; but, as already noted, the practical purpose of regeneration is not so much in

RAPID RECRYSTALLISATION IN DEFORMED NON-FERROUS METALS.

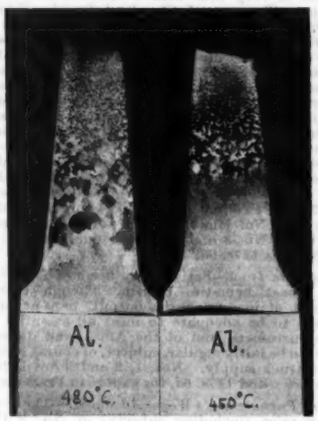


FIG. 1.
Pure Aluminium. Right hand specimen annealed at 450°C for 5 minutes; left hand specimen annealed at 480°C for 30 minutes. Photograph 10% less than natural size. (Etched with hydro-fluoric acid.)

FIG. 2.
Aluminium Alloy containing 3% copper and 20% zinc. Annealed at 450°C for 5 minutes. Natural size. (Etched with hydro-fluoric acid.)

FIG. 3
70/30 Brass. Annealed at 800°C for 5 minutes. Showing junction between coarse and fine crystals. Magnified 3½ times. (Etched with copper ammonium chloride.)

(All reduced one-third in reproduction.)

extraction and economy of heat units, but in the provision and maintenance of high temperatures to the gas and air supplies—which is not quite the same thing as thermal efficiency. Checker chambers are rarely deep enough for high thermal efficiency, and considerable margin is therefore usually available for raising steam. Under suitable conditions, evaporation varies from 1 lb. up to 3 lb. of steam per pound of coal burned in the producers—though the latter figure must indicate very poor regeneration.

Waste-heat boilers should be specially designed and well above their work as regards flue areas and heating surface, or the results will be disappointing; for though evaporation may be only 1 lb. of steam per pound of coal, the gases passing are virtually the same as if the coal were burning under the boiler, or possibly eight times as much as through a coal-fired boiler doing the same duty. These dimensions depend on the weight of coal consumed, not upon the steam raised. Waste-heat boilers are usually fitted with mechanical induced draught plant, instead of the more reliable static chimney. By attention to flue and valve design, so as to do away with all obstruction other than the boiler, it is surely possible to dispense with mechanical draught and to retain the plain chimney and add sufficient to its height to equalise matters. The operation and output of the furnace must always be the first consideration.

Conclusion.

Such are the general principles of open-hearth furnace design; and the author feels that if more attention were paid to their correct application, better performances would very often result. The data and assumptions made may not always correspond with actual conditions; but it is not a difficult matter to ascertain the latter more precisely and to amend the calculations accordingly, with due regard to the improvements it is desired to effect. The general reasoning and method will, he thinks, be found correct, and, he hopes, of value to all who are interested in the design and performance of open-hearth furnaces. It is surely better to tackle the subject *ab initio*, with a clear view of the objects and underlying principles, than try to follow blindly the practice of others—British or foreign—who may, or may not, have "got there" by accident. Let us understand why, and possibly we may be able to improve thereon.

The metallurgy and practice followed are, of course, equally important factors in any comparison of performances, but are outside the scope of this article, and must be reserved for a future paper.

RAPID RECRYSTALLISATION IN DEFORMED NON-FERROUS METALS.*

By D. Hanson, M.Sc., Member (The National Physical Laboratory).

Recrystallisation phenomena have formed the subject of many researches. Many of these have been carried out on severely deformed material, in which the study of the effects of time and temperature of annealing have been the main objects. In the case of iron the production of extremely coarse crystals in the slightly deformed metal, after suitable annealing, has been studied by Stead,† Sauveur,‡ and others, and more particularly by Chappell.* Sauveur finds that rapid recrystallisation only occurs in iron when the amount of deformation has been of a certain "critical" amount. Chappell's work does not confirm this.

Chappell shows that very coarse crystals of iron are rapidly produced on annealing deformed iron below 900 deg. C., provided that the amount of deformation has been small; the size of the crystals which are formed varies continuously with the deformation, and is greater the smaller the amount of deformation, but the temperature at which annealing commences is higher the smaller the amount of deformation.

The only work which has been published, so far as the author is aware, on similar phenomena, in non-ferrous metals and alloys, is described in a paper by Robin,† but at the moment of writing a paper by R. J. Anderson,‡ on the annealing of aluminium, is announced, in which "differential grain growth" in aluminium is described. Robin's work deals largely with the effect of time and temperature on grain size. His work on the effect of deformation prior to annealing, while it indicates clearly that the rapid production of coarse grains does occur, is not of such a character as to indicate at all clearly the relation between the amount of deformation and the recrystallisation phenomena. The manner in which deformation was produced in his experiments, by making a small indentation in a block of metal, gave a deformed region of small size, in which the transition from highly strained to unstrained material occurred over too small an area for its effect to be studied accurately.

For the following experiments a device adopted by Chappell, in his work on the recrystallisation of iron, has been used. This consists in cutting a test-piece tapered towards the centre, which, after it has been annealed, is broken in tension. In this way, with suitable tapering, varying degrees of deformation, from a maximum at the point of fracture to zero at a position between the fracture and the shoulder, are obtained. In order to obtain this the taper must be so regulated that, under the breaking load of the test-piece, the material at the shoulder is not stressed beyond its elastic limit. The amount of taper which has proved suitable varied from metal to metal, and has been determined by trial.

Aluminium.—A tapered test-piece was cut from cold-rolled aluminium sheet 0.1 in. thick. This was then annealed at 480 deg. C. for half an hour, and was afterwards broken cold. One-half of this test-piece was then re-annealed for half an hour at 480 deg. C., when it was removed from the furnace and quenched in water. On etching this sheet with hydrofluoric acid it was found that remarkably coarse crystals had developed in the neighbourhood of the shoulder where the strain was least, and that from this region the crystal size decreased fairly regularly to the point of fracture. In the material of the shoulders, which, it is assumed, had not been strained, or in which the strain had been too slight for recrystallisation to take place, the original small crystallisation of the annealed test-piece was found, the change from coarse to fine crystals being abrupt.

The other half of this test-piece was annealed by placing it for five minutes in a furnace at a rather lower temperature, 450 deg. C. In this case also coarse crystals had developed, but for a smaller distance from the point of fracture, while the same features of a gradual increase in crystal size from the point of maximum strain towards the unstrained parts are visible. This experiment indicates the great rapidity with which recrystallisation occurs, and it also suggests another important point. It will be observed on referring to Fig. 1, in which both halves of this test-piece are shown, that, in spite of the different times and temperatures of annealing, the crystal size in corresponding portions of the two halves is approximately identical, and the only noteworthy difference is that, in the specimen annealed at a higher temperature, and for a longer time, recrystallisation has proceeded for a greater distance along the specimen. When it is considered that the one specimen was placed in the furnace for only five minutes, and must have been at its maximum annealing temperature for a much shorter time than this, the rapidity with which recrystallisation has taken place is very striking.

Magnesium.—Similar experiments were carried out on pure magnesium strip 0.125 in. thick, rolled at the National Physical Laboratory, the same annealing temperatures being used as in the case of aluminium, and the same results were obtained. The actual size of the crystals produced under similar circumstances was slightly less, though not markedly so.

Zinc.—In the case of zinc, thin sheet 0.04 in. thick was first annealed at 150 deg. C. for half an hour, and after straining the two halves were annealed, one at 150 deg. C. for half an hour, and the other at 300 deg. C. for five minutes. In the case of the 150 deg. C. annealing, recrystallisation proceeded for a distance of, approximately, ¾ in. from the fracture; when annealed at 300 deg. C. for only five minutes, recrystallisation occurred right up to the shoulder, and the grain size which was developed was considerable. In this case, in which the times of annealing at high and low temperature are in the reverse order to those used for aluminium, the same observation was made that, speaking generally, crystals of approximately the same size were produced in corresponding positions in the test-pieces, i.e., at positions of equal deformation. The only marked effect of an increase in annealing temperature had been to extend the range of recrystallisation towards the less deformed end of the specimen.

Lead.—The production of crystals of varying size, from small to very coarse, corresponding to varying degrees of strain, was confirmed in the case of lead, an annealing temperature of 200 deg. C. being used.

Copper.—Copper shows the same phenomenon. A strip of pure copper similarly treated at 800 deg. C. for five minutes developed new crystals measuring up to $\frac{1}{10}$ in. diam. Crystal twinning was quite well marked in this metal.

Solid Solution Alloys.

It was thought that this phenomenon might be less marked in solid solutions than in pure metals. Solid solutions generally appear to require a somewhat higher annealing temperature than the pure metals which they contain, and it was thought that the presence of another metal in the crystal grouping might make rapid recrystallisation, with the formation of coarse crystals, difficult.

Experiment showed that any such effect was not considerable in the case of the alloys used. These were brass and an alloy of aluminium containing 3 per cent. of copper and 20 per cent. of zinc.

Copper-Zinc-Aluminium Alloy.—In this alloy, which in the fully annealed state is homogeneous, but which

* Note submitted to the Institute of Metals, Wednesday, September 11, 1918.

† Stead, Journal of the Iron and Steel Institute, 1898, No. I., page 145.

‡ Sauveur, Proceedings of the International Association for Testing Materials, Sixth Congress, 1912, vol. ii.

* Chappell, Journal of the Iron and Steel Institute, 1914, No. I., page 460.

† Robin, *Revue de Métallurgie*, 1913, vol. x., page 732.

‡ Robert J. Anderson, Journal of the Faraday Society, July 23, 1918.

may have contained a little undissolved $CuAl_2$, recrystallisation is not appreciably less pronounced than in pure aluminium. One-half of a test-piece, which was annealed for five minutes at 450 deg. C., is shown in Fig. 2. It presents exactly the same general features of a gradual increase in crystal size up to a maximum, followed by an abrupt decrease, as has been noticed in the case of pure aluminium.

70 : 30 *Brass.*—70 : 30 brass gave exactly similar results. The junction between coarse and fine crystals is shown in Fig. 3. This specimen was annealed for five minutes at 800 deg. C. The size of the coarse crystals which were developed is approximately the same as those produced in pure copper by similar treatment.

While it is realised that these results are in no way complete, and that considerable investigation is required before this remarkable phenomenon can properly be understood, yet it may be claimed that they have an important bearing on the recrystallisation of metals. In the case of a metal which has been uniformly strained, it is known that, in general, grain size produced by annealing is dependent on both the time and temperature of annealing. It would appear that the amount of previous strain has, in some cases, an even more profound effect. The extreme rapidity with which very coarse grains are produced under favourable conditions is most striking, while comparison between annealings which have been carried out on exactly similar specimens for widely differing periods of time indicate that, once the first rapid recrystallisation is effected, longer annealing at the same temperature has a relatively slow effect on the newly formed grains. It would appear also that for every degree of deformation there is a critical temperature, or, perhaps, range of temperature, at which recrystallisation commences. Whether very prolonged annealing has the effect of appreciably widening this range remains to be tested.

The results described in this Note suggest that the following law of annealing is probably applicable to all strained metals and solid solutions :—

For every degree of deformation there is a critical recrystallisation temperature at which crystal growth is extremely rapid, and the size of the crystals produced by this rapid growth is the greater the smaller the amount of deformation preceding such annealing. The rate of increase in size of the newly-formed crystals with prolonged time and increased temperature of annealing is small compared with their rate of growth at the critical temperature.

Much further work is necessary before it can be said that this law is established. More especially is it necessary to study the first stages of this rapid growth, in order that the reasons which underlie it may be understood. The effect of allotropic transformations on this growth must also be studied. Coarsely crystalline iron is refined by heating through its Ac3 point, but, according to Chappell, not by passage through Ac2. Sherry, however, finds that refining is sometimes obtained at Ac2. Robin states that zinc and nickel both fail to become refined by passing through their critical points.

Alloys containing more than one constituent have not been examined. From analogy with steel it is expected that in these alloys coarse crystal growth will be limited by the presence of a second constituent. In any case, it is obvious that such recrystallisation can only occur in the continuous phase.

The effect of coarse crystallisation of this kind on the mechanical properties of materials also remains to be investigated. It is known that iron and very mild steels become weak, especially under impact and fatigue, as a result of this grain growth, and it is probable that a similar effect will be found in some alloys.

The author wishes to express his indebtedness to Sir Richard T. Glazebrook, C.B., F.R.S., Director of the National Physical Laboratory; and especially to Dr. W. Rosenhain, F.R.S., for his interest, advice, and encouragement during the course of this work.

Women's War Work.—An exhibition illustrating women's war work was opened last Monday, at the Whitechapel Art Gallery; it is to remain open until Wednesday, November 20. The exhibition illustrates the war work of women in its various aspects, economic and philanthropic. The Whitechapel Art Gallery is near Aldgate East Station (District Railway) and Aldgate Station (Metropolitan Railway).

Illuminating Gas from Wood and Peat.—Owing to the coal shortage, the town of Horsens in Denmark was obliged to try gas-making from wood and peat; the latter was air-dried by stacking. The experience was not very satisfactory, as was natural with a somewhat improvised plant. Horizontal retorts were used, hand-fired; the retorts took charges of 50 kg. or 60 kg. of material, and the gas yield averaged 30 cub. m. per 100 kg. of material. The pitch accumulating in the hydraulic mains gave the first trouble, and the pitch was, moreover, of a poor quality. The charcoal remaining in the retort gave a good fuel for gas producers when wood has been retorted; the peat residue was inferior, however, and had to be disposed of as a second-rate fuel. The gas was of low candle-power, and had a low calorific value, as it contained about 25 per cent. of carbon dioxide; the naphthalene in it blocked the distributing mains, and the acetic acid in the gas had to be neutralised by the addition of some coal gas to the wood or peat gas, which itself was not rich in ammonia. The ammonia recovery did not prove profitable, hence, but the tar fetched a good price. There was trouble finally with the burners, the air supply of which had to be adjusted to suit the composition of the gas, and comparatively more gas was burnt than formerly.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—The only drawback to the intense activity in the steel-making industry is the continued and ever-increasing scarcity of fuel. What is perhaps the worst feature of this shortage is the fact that there seems little prospect of much improvement, at least for some time to come. Without question the steelmakers are forging ahead, and by their efforts keeping the Clyde shipbuilders so well supplied with the necessary materials —ship and boiler plates, sections, &c.—as to enable them in turn to make distinct progress with the urgent contracts at present in hand. The effect of the enormous output of steel is likewise stretching further, and by authority of the Admiralty Superintendent a considerable quantity of steel manufactured in the West of Scotland is being sent to England for the construction of fabricated ships and other purposes. This concession must be of immense benefit. A limited quantity of steel going to France and Belgium for war purposes represents the entire export meantime.

Malleable Iron Trade.—Both in their iron and steel departments, malleable iron makers continue output on a large scale. Practically the whole of this is being utilised for purposes of national importance, and, through the scheme of division now in operation is being distributed where most urgently required.

Scotch Pig-Iron Trade.—The iron smelters are as fully employed as is possible under the present circumstances of shortage of raw material and fuel. Every ton produced goes rapidly into use. In the ironworks and general engineering shops, too, there is a constant call for forge and foundry iron, all of which, naturally, is required for work of national importance. As the output goes directly or indirectly for war purposes nothing can be spared for shipment abroad, other than some very small lots for Allied uses. No alteration in price has been reported.

Sale of a Clyde Shipyard.—Messrs. Murdoch and Murray, shipbuilders, Port Glasgow, have just disposed of their business to Messrs. John Slater, Limited, shipowners, London, who will in future run the shipbuilding yard at Port Glasgow as a new branch of their already existing business. It is now close on half a century since the establishment of the old firm by Mr. James Murdoch and Mr. Henry Murray, and in that time many coasting and general cargo vessels have been turned out. As Messrs. John Slater, Limited, are the managing owners of a number of cargo steamers the new venture ought to be advantageous to their interests.

Clyde Shipwrights' Wages Claim.—In consideration of the fact that the Clyde shipwrights resumed workfast week, in accordance with the Government mandate the Committee on Production has arranged to hear the men's claim for a minimum weekly wage of 5*l.*, at a special sitting in Glasgow to-day (Wednesday).

Personal.—Messrs. Thomas Smith and Sons announce that their business has been converted into a private limited company, and that they now trade as Thomas Smith and Sons (Rodley), Limited. The change is in the name only, the personnel remaining the same.— In consequence of the rapid growth of their business as manufacturers of concrete machinery, Messrs. Winget, Limited, have added a North of England office to their numerous branches at home and abroad. The address is 40, Albert-road, Middlesbrough, where Messrs. Winget's late secretary, Mr. Calvert Griffiths, acts as manager.— Mr. Thomas McLeod informs us that he has purchased the controlling interest in the Power Plant Company, Limited, West Drayton, Middlesex, and the management is now purely British. The new managing director is Mr. R. J. McLeod, the assistant general manager, Mr. W. E. Sykes, the technical staff remaining as before.

Iron and Steel Trades.—The following resolution on Lord Balfour of Burleigh's Departmental Committee Report on the Iron and Steel Trades was passed unanimously by the Council of the British Federation of Iron, Steel, Tinplate and Metal Merchants at a council meeting held in London on September 27: "This council, while most cordially desirous of forwarding every effort to improve the efficiency and increase the volume of British production, is strongly of opinion that the rehabilitation and expansion of British trade after the war will not be furthered but seriously handicapped by any attempt to drive out of business the merchants of this country whose activities must in the future, as in the past, conduce to the mutual advantage of producer and consumer. This council would view with grave concern the adoption of the recommendations of Lord Balfour's Committee on Trade after the War in favour of the establishment of a national selling agency or agencies by manufacturers in the iron and steel trade. Such an agency or agencies would, in the opinion of this council, not only jeopardise the existence of the merchant community, which has hitherto carried on successfully the marketing of British iron and steel, but would, also, seriously threaten the interests of consumers and the freedom of trade generally. If merchants are thus to be deprived of their living under the auspices of Government Departments they are entitled to claim compensation from the State for the destruction of their businesses. This council notes the recommendations of the committee that various committees and advisory bureaus should be set up after the war under the authority of Departments of State to consider trade questions. Should these bodies be established this council urges the claim of the merchants to adequate representation thereon."

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron market is very firm with a fair amount of business passing. Shortage of Cleveland foundry iron is still pronounced, and indeed considerable difficulty is being experienced in placing orders under the October allocations to home consumers. The question is not altogether one of shortage of production, as some makers have stocks of No. 3 quality, but labour to lift it is difficult to secure, and in addition, there is only a limited number of trucks available, and iron producers prefer using them to despatch forge pig-iron direct from the pig-iron beds, to attempting to lift stocks. Forge quality is quite plentiful, and is selling freely both for early and forward delivery. Shipments of Cleveland iron to the Allies are reported improving. For home consumption, No. 3, No. 4 foundry, and No. 4 forge, are all quoted 95*s.*; and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are 122*s.* 9*d.* and No. 1 is 127*s.* 9*d.*

Hematite Iron.—Satisfactory account is given of the East Coast hematite branch. Though there is no prospect of increasing the output, present production appears to be adequate to meet all essential needs of home customers, and of the Allies, and deliveries are stated to be fairly regular, subject, of course to variations in the truck supply. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use; and 147*s.* 6*d.* for export to France and Italy.

Blast Furnacemen's Wages Advanced.—The average net selling price (including subsidy) of No. 3 Cleveland pig-iron for the months of July, August and September, is certified at 118*s.* 10·86*d.* per ton, as compared with 107*s.* 10·68*d.* per ton for the preceding three months, the advance in price in the third quarter of the year thus being 11*s.* 10·18*d.* per ton, which means an advance in blastfurnacemen's wages of 13·75 per cent., raising wages from 94·75 per cent. above the standard to 108·50 per cent. above the standard. The advance takes effect from the 6th inst.

Manufactured Iron and Steel.—There is no abatement in pressure for delivery of manufactured iron and steel, and the enormous production is being distributed with most commendable expedition. Prices, all round, are very stiff. The following are among the principal market quotations :—Common iron bars, 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; triple best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.* 10*s.*; steel hoops, 18*l.*: and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*—all f.o.b. at makers' works. Export quotations are not fixed, but they may be given as approximately 40*s.* above home prices.

Manufactured Ironworkers' Wages.—According to the accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, the average net selling price of iron bars and angles for the two months ended August 31 last was 14*l.* 11*s.* 9·96*d.* per ton, as compared with 14*l.* 2*s.* 8·62*d.* per ton for the previous two months. This carries an advance of 6*d.* per ton on puddling, and 5 per cent. on all other forge and mill wages, to take effect from the 30th ult. In accordance with the Ministry of Munitions lines of settlements on January 3 last, and February 20 last, this advance will merge into the 12½ per cent. bonus, and the 7½ per cent. bonus granted under those settlements.

Coke.—The situation as regards coke shows some slight improvement, but still leaves much to be desired. Supply continues short, but deliveries to the furnaces are better. Medium blast-furnace kind is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens. Sales of foundry coke to neutrals are reported at 65*s.* f.o.b.

Spanish Ships Sunk by Germany.—The French journal *La France Maritime* reproduces a Spanish illustrated placard showing the 75 vessels of Spain's mercantile fleet which have been sunk by German submarines from 1915 down to March 30 last. The total tonnage of these 75 ships is 154,049 tons. The ships are depicted going down by the head. The name, tonnage and date of sinking is printed under each illustration.

American Coke Ovens.—We read in *The Iron Trade Review*, Cleveland, Ohio, that according to a discussion before the American Society of Mechanical Engineers at a meeting early in June last, the preliminary Government estimate places the total coke production for 1917 at 56,000,000 tons, the largest in the history of the industry. Of this total, 34,000,000 tons, or 60 per cent., was beehive coke, and 22,000,000 tons, or 40 per cent. was by-product coke. This ratio, however, is likely to be reversed before long, for the by-product plants now under construction in the United States will have a capacity of 13,800,000 tons. As a majority of these plants will be in operation this year, it seems safe to prophesy that at some time during the latter part of the year, the production of by-product coke will exceed the beehive output. The total capacity of the by-product ovens in the United States now in operation or under construction will be about 40,600,000 tons annually. This is more than 5,000,000 tons above the maximum production of the beehive ovens reached in 1916, when all conditions were favourable to bringing out the greatest possible production from the beehive plants.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Vickers, Limited.—At their annual meeting held on Tuesday in Sheffield, Vickers, Limited, increased their capital to 13,500,000*l.* by the creation of 6,450,000 new ordinary shares.

Iron and Steel.—Business in the iron and steel trades of the district is of a varied and constantly changing character. The great offensive has given an increased impetus to the demand for steel of all qualities for shell and munition purposes. Reports show that there is less pressure for acid open-hearth qualities, but the whole of the output of the local basic furnaces is going direct into consumption. The crucible steel department is distinctly easier. An excessive supply is reported of steel-making alloys, stocks in many instances being very heavy. The position of the tool steel industry goes from bad to worse. The pressure for tools of all descriptions becomes daily heavier, but manufacturers are working to the extent of their powers of production, and orders continue to accumulate. The market is denuded of supplies, and for weeks there has been no appreciable improvement in the output. Manufacturers having got well on the top of the munition demand in many instances, has allowed a recovery of commercial trade which could not be entertained when restrictions were severe. For some weeks it has been possible to deal with low priority orders, and export certificates have been easier to obtain.

South Yorkshire Coal Trade.—The output is gradually improving, but the heavy demand prevents any surplus reaching the open market. Steam coals are in active request, supplies being very short in some directions. The pressure on collieries for house coal, especially for districts outside the London area is greater than ever, and many merchants are short of supplies. The commandeering of traders' wagons is also having a depressing effect on business. Maximum rates rule. Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

STEAM HYDRAULIC PLATE SHEARS: ADDENDUM.—In our issue of October 4 we illustrated and described a very fine set of steam hydraulic plate shears constructed by Messrs. Duncan Stewart and Co., of Glasgow. We inadvertently omitted to mention that the intensifier is covered by patents held by Messrs. Davy Brothers, Limited, of Sheffield, and over these patents Messrs. Duncan Stewart and Co., Limited, have working rights.

RHINE-DANUBE SCHEMES.—According to several German journals, the Bavarian Government has allocated the sum of 2,000,000 marks for the execution of the plans for a ship canal from Aschaffenburg to the frontier of the Empire, below Passau. On the other hand, the *Zeitschr. des Oesterr. Ingenieure und Architekten Vereines* states that a company has been formed, which commenced operations in January last, with a capital of 5,000,000 marks to elaborate the scheme for and undertake the necessary preliminary work in connection with this canal.

SWITZERLAND AND THE WATER POWER OF THE UPPER RHINE.—A Rhine Navigation Congress held in Basle early in July, attended by representatives of the Swiss Federal and cantonal authorities and all the Swiss navigation associations, and also by guests from Germany and Holland, expressed disapproval of the project of canalising the Rhine between Strassburg and Basle, says the *Lokal Anzeiger*. The Congress was in favour of preserving a free navigable connection between Switzerland and the North Sea, and this object can be obtained only by regulating the reach in question. A resolution was adopted requesting the Swiss Federal Council, in virtue of the Vienna Congress Act and the Rhine Navigation Act of 1868, to protest against the German project for the construction of power stations between Strassburg and Basle, and to preserve the international claims and the just interests of Switzerland by the method of "objective explanation and friendly agreement." On the other hand, the Congress considered that the Rhine between Basle and the Lake of Constance should be canalised.

DIP-HORIZON MEASUREMENTS ON THE GALILEE AND CARNEGIE.—Communicating the results of over 3,000 observations taken during ten years at sea by the Department of Terrestrial Magnetism to the Philosophical Society of Washington last April, W. J. Peters stated that the sea-horizon was hardly ever elevated by atmospheric refraction by more than 2·7 minutes of arc above its normal position for a height of eye of from 18 ft. to 24 ft. In a few cases elevations of 10 minutes and even of 15 minutes had been observed, however. These cases were probably confined to the borders of equatorial and polar currents and to small areas of water swept by breezes blowing directly off heated lands or off ice fields. Comparing the data collected with those of other observers, Peters concluded that the standard tables of dip of horizon were sufficiently accurate for the navigator and could not be improved by the introduction of a temperature-difference argument. There are instruments allowing of making corrections for these differences; but they are hardly suitable for observations at sea.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—On the whole the general conditions on the local markets are somewhat easier. Fortunately there are practically no stoppages in the coalfield at the present moment. This does not mean exactly that there have been no disputes. As a matter of fact these continue to be as numerous as ever, but they are mainly of comparatively minor importance, and are being expeditiously dealt with by the Standing Joint Disputes Committee of the Welsh Coal Board. This committee now meets weekly; the last was held yesterday, when over a score of local disputes were dealt with satisfactorily. The result is that production is fairly well maintained, although it is hardly yet what it ought to be and there is a great scarcity of some classes of coal. The Admiralty collieries are kept working at considerable pressure and the supply is by no means equal to the demand. The best classes of even small coals are quickly taken up but the lower grades are easy, the only qualities showing anything like steadiness being the best bunker descriptions which are in good demand. The supply of pitwood continues ample.

Newport.—A fairly steady tone characterises the market for Monmouthshire coals, and collieries as a whole are fairly well stemmed. There is a good inland demand, and, with better railway facilities, deliveries would doubtless be considerably better. Smalls are weak, except coking descriptions, which are maintaining a firm tone. Coke is being retained for inland consumption, and hardly any licences for shipment have been granted for some time past.

Colliery Workers Demand for Shorter Hours.—The demand of the men in the mechanical departments at the collieries in the South Wales coalfield for the general establishment of an eight-hour day is causing some measure of anxiety. Some of these men are members of the Miners' Federation, while others are members of the Enginemen, Stokers and Craftsmen's Association and the two rival organisations seem to be competing as to which will first succeed in securing a concession of the new demand. The Miners' Federation are bent upon absorbing, sooner or later, the smaller craft organisation, and advantage is taken of every opportunity to secure this end. Unfortunately the policy pursued is such as tends to create a measure of unrest, and the industry and the public have to suffer. The demand for an eight-hour day for these classes of workmen was submitted to the owners on Monday by the Craftsmen's Association, when it was pointed out by the owners' chairman (Mr. T. H. Deakin) that if the proposal were adopted it would mean that an additional number of men must be employed, whereas at the present time such men are not available, and that the application is being made at a most inopportune time, as it would, if conceded, mean a reduction in output at a time when the country requires the maximum production. Moreover, it is necessary that surface craftsmen should be available at the beginning and at the end of the shift, as the question of the safety of the underground workmen is involved in so far as provision must be made for repairs in the case of a breakdown occurring while men are being lowered into, and wound out of the collieries. For these reasons the owners refused to grant the concession, but it is not likely that the agitation will be discontinued, and a conference of craftsmen is now being convened to decide upon a course of action in view of the owners' decision.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new series (No. 65) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this series can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

ELECTRIC RAILWAY FROM ST. PÖLTEN-MARIAZELL, AUSTRIA.—An advertisement of the Austrian Siemens-Schuckert Werke, in an Austrian journal, gives some particulars of this new line. It is 91·3 km. long and of 760 mm. gauge. The greatest gradient is 27 per cent.; the tension of the line conductor 6,000 volts at 25 cycles per second. The weight of the locomotives used is 47 tons, and each is fitted with two 250 h.p. motors. The normal speed is 35 km. per hour, and the normal tractive effort of each locomotive 3,800 kg.

AMMONIA WATER FROM GAS WORKS AS FERTILISER.—Some good results obtained by using ammonia water as a fertiliser have been obtained by Dr. F. Mach at the Agricultural Institute, Augustenberg, Baden. At the same time great caution is advised in this use of gas water owing to its poisonous character. The water in question contained on an average 1·4 per cent. of ammoniacal nitrogen and only little mineral substances, there being 1·11 per cent. of dry residue and 0·008 per cent. of ignition residue; but there were also present 0·24 per cent. of phenols, 0·23 per cent. of sulphuretted hydrogen, 0·196 per cent. of hydrosulphocyanic acid, and traces of hydrocyanic acid. For these reasons the water must be spread over the soil and ploughed under about two weeks before potatoes or seeds are sown. Ammonia in itself is, moreover, not in general a sufficient fertiliser; most crops also need potash or phosphate. If it were not for the poisons present, however, the gas water would be superior to liquid farmyard manure.

NOTICES OF MEETINGS.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE, ENGINEERING SOCIETY.—Friday, October 11, at 5.15 p.m. General meeting, to be held in the Society's Rooms. Presidential Address on "Determination of Stresses by Means of Polarised Light," by Professor E. G. Coker, F.R.S., M.Inst.C.E.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday Evening, October 12, at 6.30 p.m., at the Grand Hotel, Manchester:—(1) Presentation of the "Constantine" Medal to C. A. Edwards, D.Sc. (Manchester University), for his paper, entitled "The Hardening and Tempering of Steel"; (2) Inaugural Address by the president, Mr. Joseph Butterworth, M.I.Mech.E.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Saturday, October 12, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C., Mr. D. Wilson, A.M.I.E.E., Technical Adviser to the Coal Controller of the Board of Trade, Coal Mines Department, has consented to address the members and their interested friends on the vital question of "Fuel Economy," the president presiding.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, October 15, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read: "Some Notes on the Geology of the Persian Oilfields," by Mr. H. G. Busk, B.A., F.G.S., and Mr. H. T. Mayo, B.A., F.G.S.

THE JUNIOR INSTITUTION OF ENGINEERS, NORTH-EASTERN SECTION.—Tuesday, October 15, at 7.15 p.m., at the Mining Institute, Neville-street, Newcastle-on-Tyne. Discussion on Coal Conservation Sub-Committee's Report, to be opened by Mr. M. Ward.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, October 17, at 7 p.m., at the Birmingham Chamber of Commerce, New-street. Paper by Mr. F. Johnson, M.Sc., and Mr. W. H. A. Robertson, M.Inst.Met.(Bradford), "The Rolling of Metals."

THE INSTITUTION OF GAS ENGINEERS (INCORPORATED).—Thursday and Friday, October 17 and 18, at 10.30 a.m., each day, a special general meeting of the Institution will be held, at the Institution of Civil Engineers for the consideration of the following: (1) Preliminary Report of the Gas Investigation Committee, Mr. James W. Wood, M.Sc., Research Chemist. (2) Life of Gas Meters Research Committee's Report; "Unaccounted for Gas," by Mr. B. R. Parkinson, M.I.Mech.E.; "The Corrosion of Dry Meters," by Mr. J. G. Taplay, Chief Analyst to the Gas, Light and Coke Company. (3) Report of the Refractory Materials Research Committee: "The Corrosive Action of Flue Dust on Fire Bricks," by Mr. Walter Emery and Dr. A. Scott, of Stoke-on-Trent. Dr. J. W. Mellor, reporter.

THE CERAMIC SOCIETY, REFRACTORY MATERIAL SECTION.—Thursday and Friday, October 17 and 18 in the Technical College, Swansea:—On Thursday October 17, at 11 a.m., the following papers will be read and discussed: "Notes on the Distribution of Refractory Materials in South Wales," by Mr. J. Allen Howe, B.Sc., F.G.S.; "Magnesite as Raw Material," by Mr. T. Crook; "Silica Brick Manufacture," by Mr. G. W. Mottram; "Corrosive Action of Flue Dusts on Firebricks," by Dr. J. W. Mellor and Mr. W. Emery. On Friday, October 18, at 10 a.m., there will be read: Second Report of Committee on the Standardisation of Methods of Testing, presented by the Secretary, Dr. J. W. Mellor: "Zirconia—Its Occurrence and Application," by Mr. H. C. Meyer; "Refractories in the Zinc Industry," by Mr. J. A. Audley, B.Sc. In the afternoon there will be visits to works, followed by an Evening Lecture (open to the public), "Science and the Local Industries," by Mr. Cosmo Johns.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 18, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Papers: "A Law Governing the Resistance to Penetration of Metals which are Capable of Plastic Deformation, and a New Hardness Scale in Fundamental Units," by Professor C. A. Edwards and Mr. F. W. Willis, of Manchester; "The Value of the Indentation Method in the Determination of Hardness," by Mr. R. G. C. Batson, of Teddington, Associate Member; and "The Ludwik Hardness Test," by Dr. W. Cawthorne Unwin, F.R.S., of London, Past-President.

THE ROYAL SANITARY INSTITUTE.—Friday, October 18, at 2 p.m., to visit Messrs. Pilkington's Tile and Pottery Company's Factory, Clifton Junction, and at 6.30 p.m., at the College of Technology, Manchester, when a discussion will take place on "Welfare Work in Factories and Workshops." To be opened by Professor J. Radcliffe, M.Sc.Tech. (Member of Council) and Miss Ethel Brown (Welfare Secretary, Messrs. John Bright and Brothers, Rochdale). The chair will be taken at 6.30 p.m. by Mr. Philip Boobbyer, M.D., M.S. (M.O.H., Nottingham) (Member of Council).

DISCOVERY OF ORE DEPOSITS IN LAPLAND.—Investigations undertaken in Lapland at the instance of the Swedish State Geological Department have led to the discoveries of further vast deposits of ores in the southern part of the country. At Iovavattnet and Klippan, Färne, large deposits of copper ore have been found, also at Unnagrejas, at Lake Virisen. Especially in the latter locality the deposits appear to be of great magnitude. There ore veins are as much as 90 m. broad and 2,000 m. in depth, but these huge deposits are difficult to break and to exploit. At Vardarfjäll the existence of deposits of copper ore in large quantities has been ascertained, and the investigations continue in that neighbourhood. Rich lime deposits have been discovered at Strömsula, and interesting and valuable discoveries of other minerals have been made in other localities.

CANADIAN VICKERS SHIPBUILDING WORKS AT MONTREAL.

(*For Description, see Page* 395.)

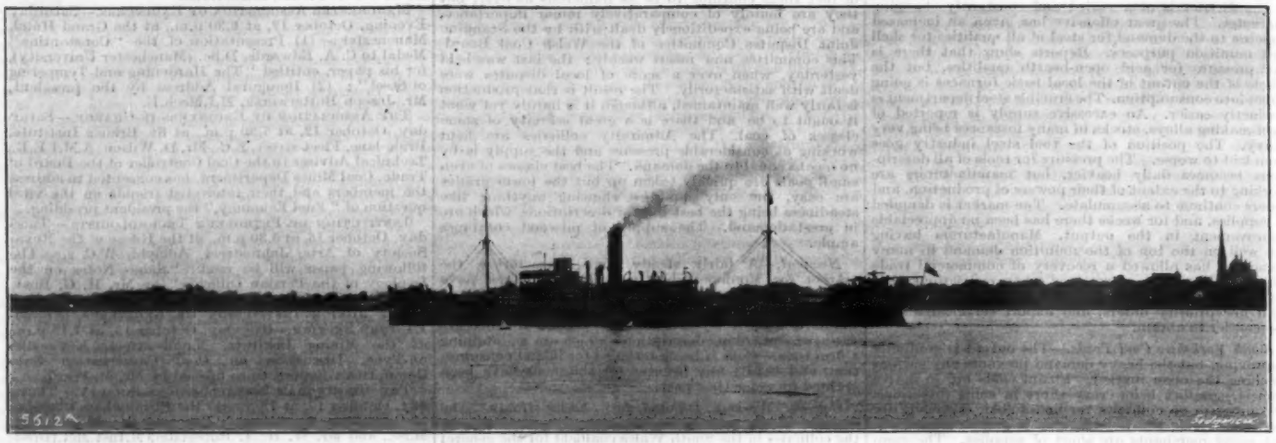


Fig. 11. The Largest Ocean-Going Cargo Ship Built in Canada.

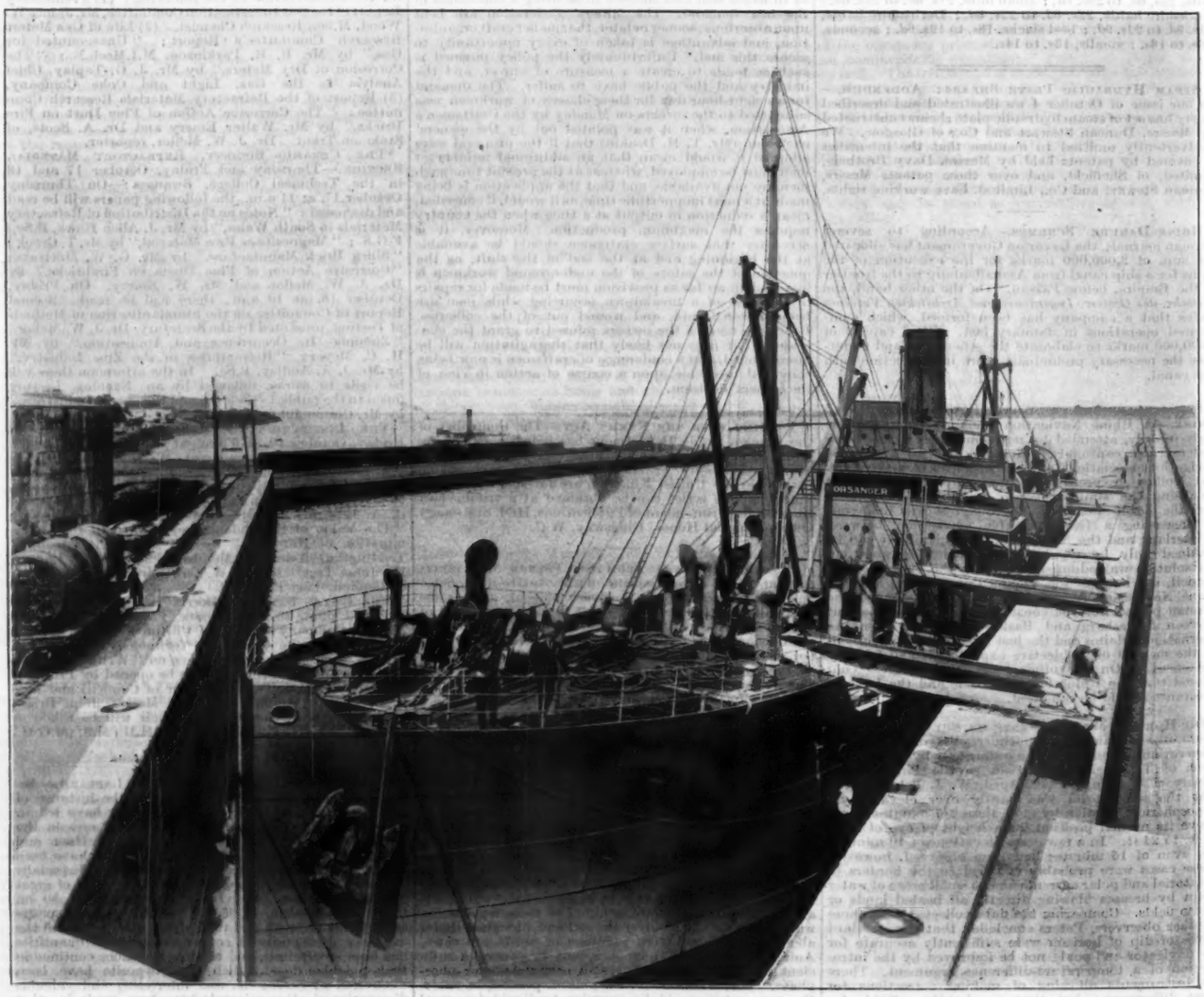


Fig. 12. S.S. "Porsanger"

THE SHIPBUILDING AND ENGINEERING WORKS OF CANADIAN VICKERS, LIMITED, MONTREAL.

(*For Description, see Page* 395.)

Fig. 1. Motor Boats under Construction.

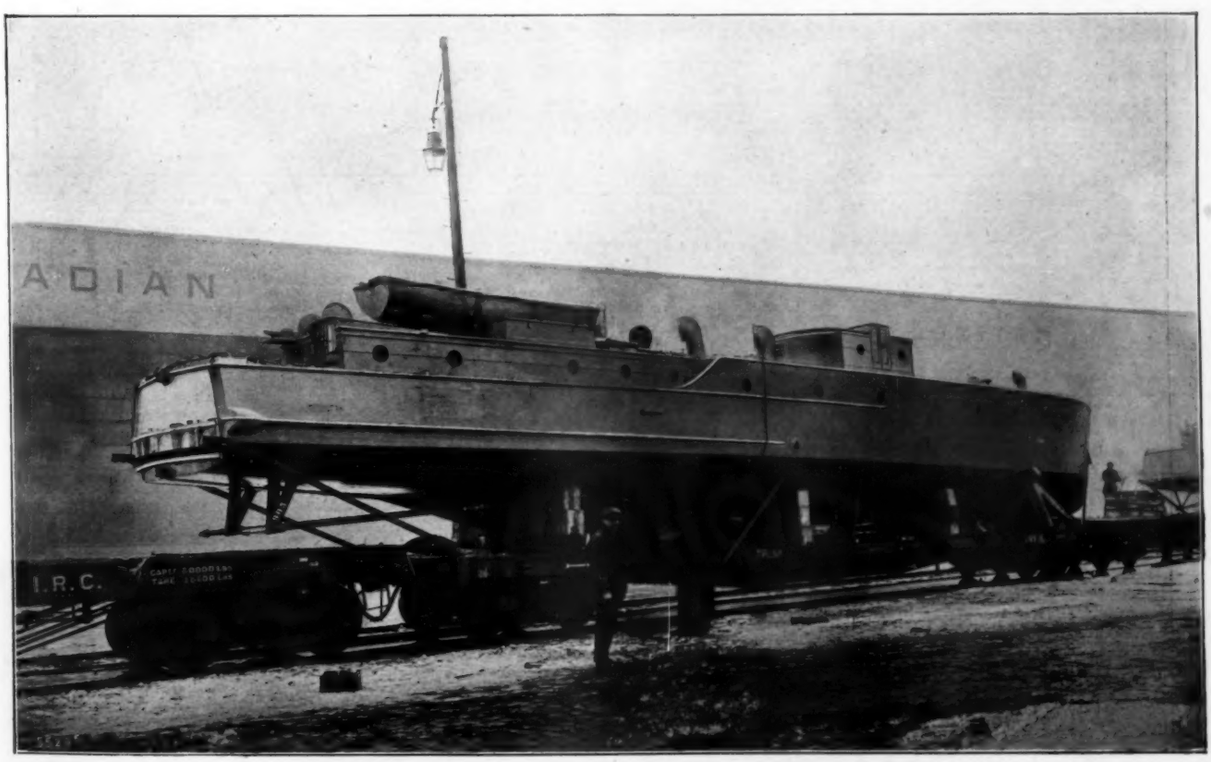


Fig. 2. Motor Boat Loaded on Railway Trucks.

(*To face page* 396.)

THE SHIPBUILDING AND ENGINEERING WORKS OF CANADIAN VICKERS, LIMITED, MONTREAL.

(*For Description, see Page* 395.)

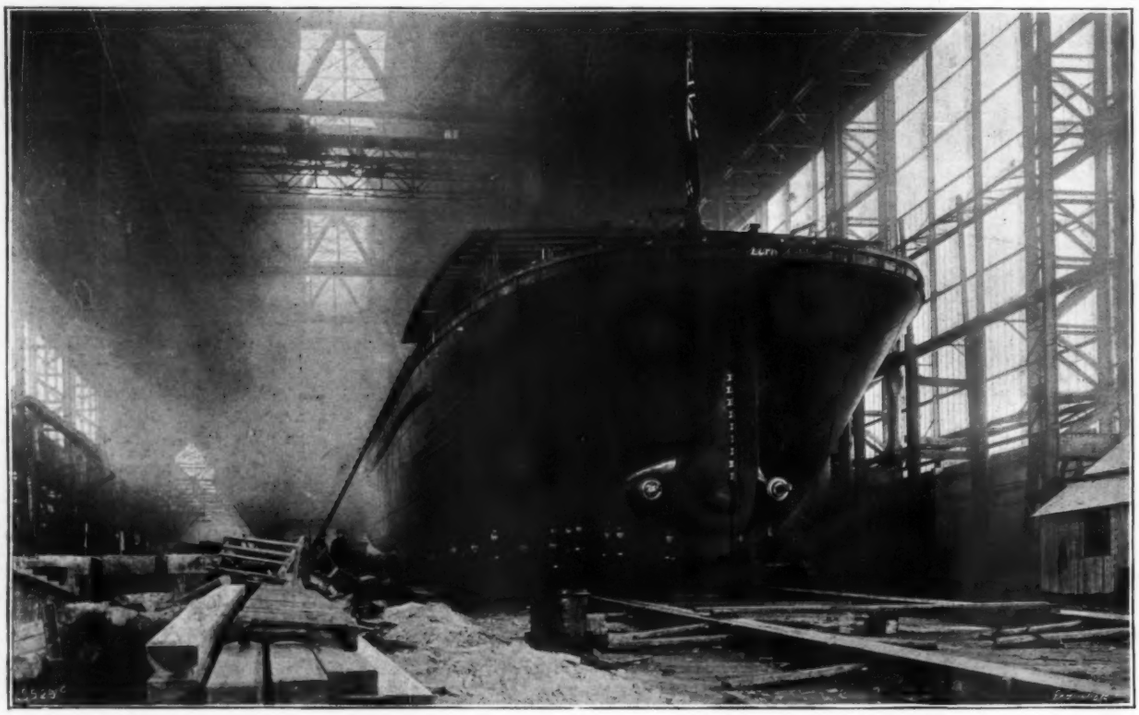


Fig. 3. Dredger Ready for Launching.

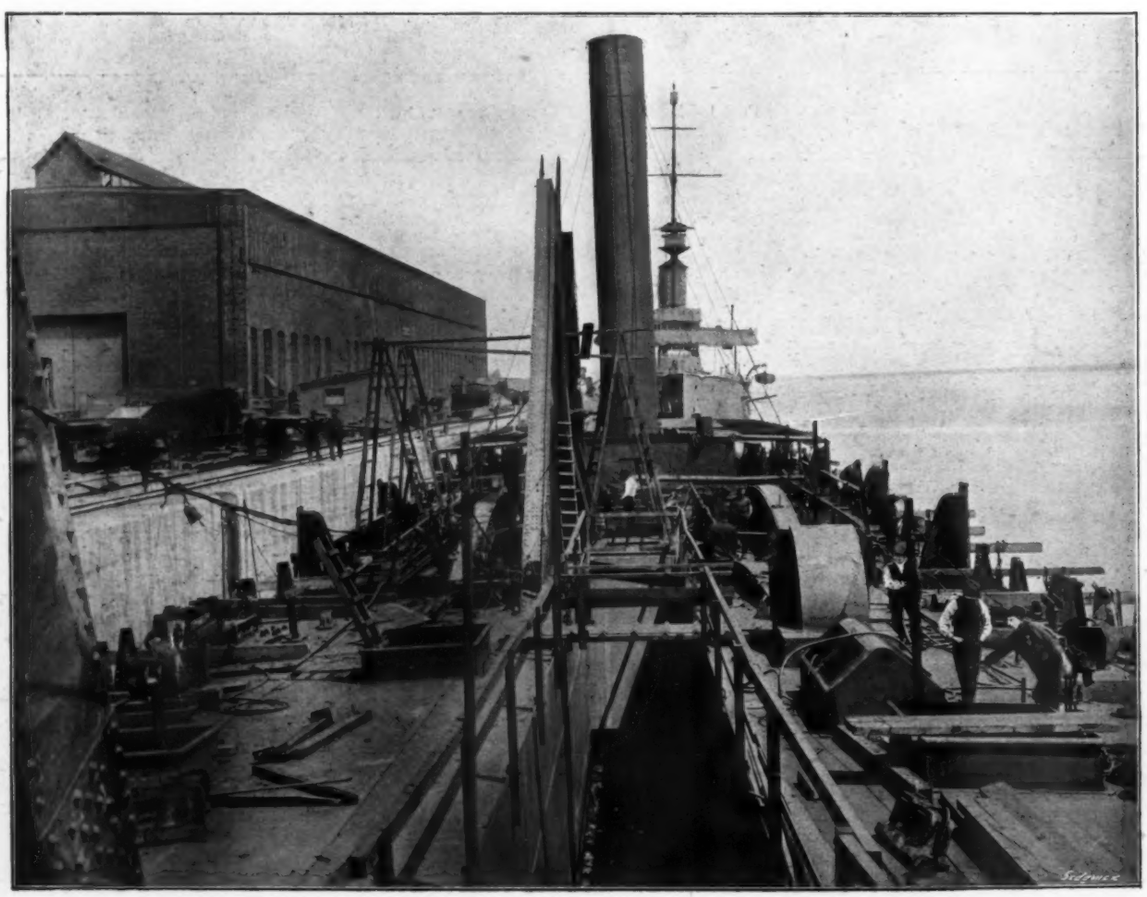


Fig. 4. Dredger being Fitted Out.

THE SHIPBUILDING AND ENGINEERING WORKS OF CANADIAN VICKERS, LIMITED, MONTREAL.

(*For Description see Page* 395.)

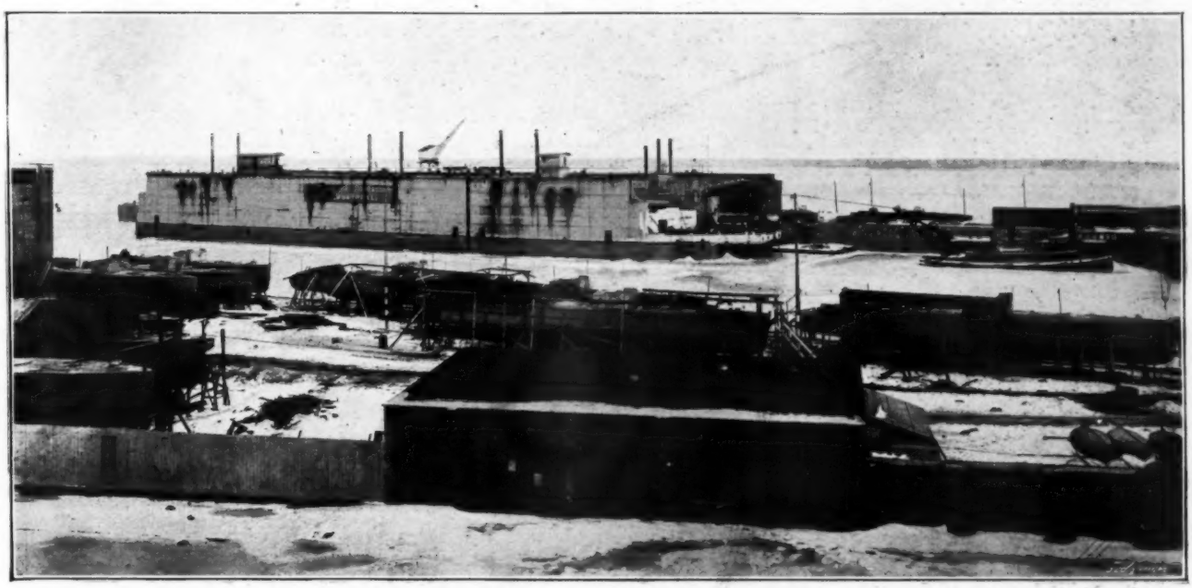


Fig. 5. General View of Basin with Floating Dock.

Fig. 6. Standard Ship in Berth No. 3.

Fig. 7. Standard Ship in Berth No. 4.

THE SHIPBUILDING AND ENGINEERING WORKS OF CANADIAN VICKERS, LIMITED, MONTREAL.

(*For Description, see Page* 395.)

Fig. 8. Boilers in Course of Construction.

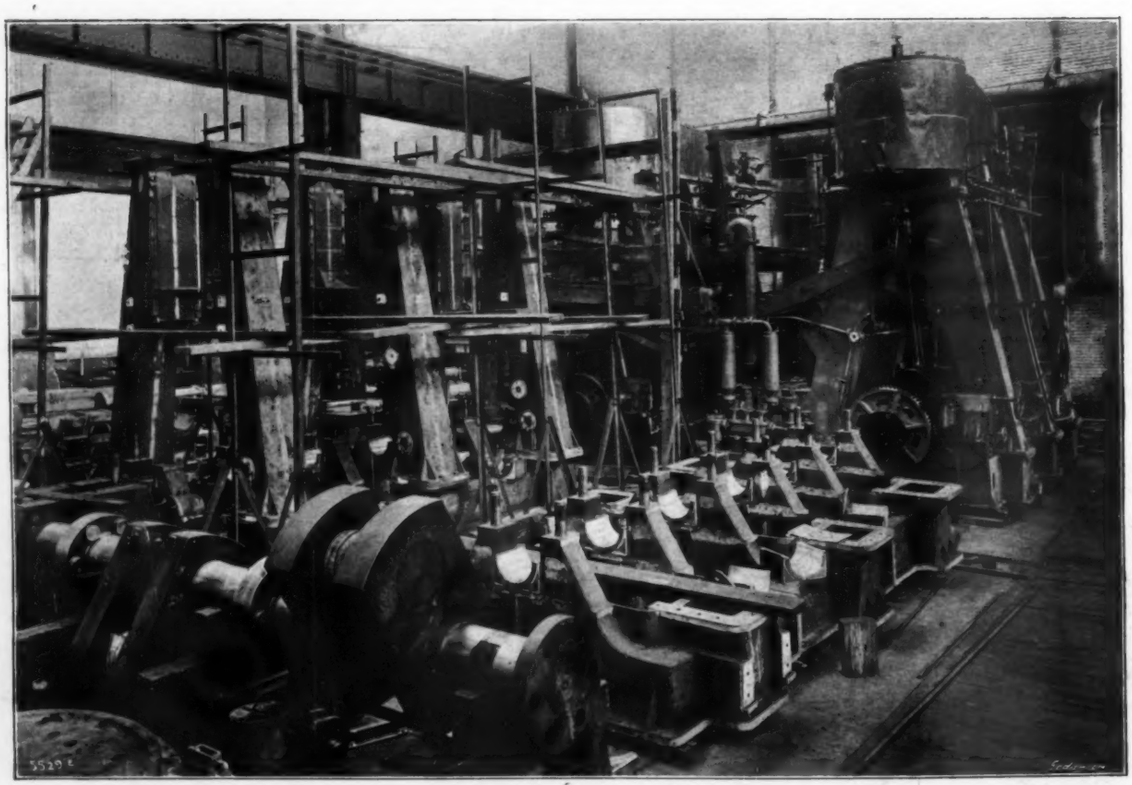


Fig. 9. Erecting Marine Engines for Standard Ships.

(*To face page* 397.)

AGENTS FOR "ENGINEERING."

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 0
For Canada—	
Thin paper copies	£2 5 0
Thick " "	£2 9 6
For all other places abroad—	
Thin paper copies	£2 9 6
Thick " "	£2 14 0

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—8663 and 8598 GERRARD.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 405.

ENGINEERING.

FRIDAY, OCTOBER 11, 1918.

THE MECHANICAL PROPERTIES OF MATERIALS.

IT was an eminent French mathematician who reproved one of his pupils for commencing a demonstration with "It is known that." "Quite true" was the comment. "But who taught us the fact?" We are, perhaps, all too prone to accept as a matter of course our inheritance as heirs of all the ages, and to be slow to recognise the immensity of our debt to bygone generations of investigators. Their work may have been conducted with crude appliances, such as to excite the contempt of the youthful student in a modern laboratory, and their rough approximations have long been superseded by figures obtained later by men often of smaller mental calibre, and there is thus much danger that as time goes on even important pioneering work may fade into oblivion. It is well therefore that we should occasionally be presented with such an historical survey of certain fields of research as that with which Professor Unwin opened his Thomas Hawksley lecture on "The Mechanical Properties of Materials," which he delivered to the Institution of Mechanical Engineers last Friday. The task could not possibly have fallen into better hands. As Fairbairn's assistant, Prof. Unwin was associated with much of the pioneering in this field, and his extensive reading and well known familiarity with foreign as well as domestic investigations, combined with his practical knowledge, eminently fitted him for the task.

Galileo, the lecturer stated, was the first to experiment on the strength of materials. This he did in 1638. Some ninety years later in 1729 Muschenbroek published the results of a whole series of determinations of the tensile strength of materials which he had carried out at Leyden. Prof. Unwin showed to the meeting illustrations of the kind of specimens and of the clips used in these experiments. A noticeable feature was the use of square shoulders between the bodies and ends of the specimens, which, apart from this defect, were of very much the same shape as that used to-day. The type was certainly a great improvement on those (also illustrated by the lecturer) used by Fontenelle in 1702. On the theoretical side Robert Hooke formulated his famous law in 1638, and Young defined his elastic modulus in 1807. The familiarity of these latter names in comparison with the general ignorance of the above-mentioned experimental work of Galileo, Fontenelle and Muschenbroek, illustrates anew by how much a contribution to scientific thought outweighs even pioneering additions to scientific data.

It was not, it appears, till the earlier decades of the nineteenth century that systematic testing of materials of construction became a practice. Engineers and contractors must, of course, have had for ages past, methods of ascertaining the suitability of the materials they used, just as the native West African smith can distinguish between European mild steel and his indigenous wrought iron, which he considers by far the better article, as, no doubt, for his purposes it is. Primitive tests no doubt were largely qualitative, though, in the case of metals, bend tests having a certain quantitative character, must have been introduced at a very early date. They still form one of the most reliable indications of the structural value of a metal, and have been systematised in the Arnold testing machine, and in the simple and ingenious hand-bending machine devised some years since by Capt. Sankey. Whilst, however, the bend test differentiates bad metal from good, it does not or, at any rate, did not, afford any simple means of passing from the experimental figures to the stress which it was safe to impose on a metal. So long as complete models of a structure were tested, as was done notably in the case of the Menai Bridge, the necessity for determining the actual values of the stresses hardly existed. A model of this bridge, Prof. Unwin recalls, was made to ½ scale and tested to destruction, being broken in all six times. After each test the model was repaired and strengthened, so that whilst in the first instance it carried a total gross load of 38 tons before failure, this figure attained 89 tons in the final experiment.

The analysis of structures into struts and ties, called, however, for direct determinations of the tensile and compressive strengths of the materials of engineering. Here the French were early in the field, and Prof. Unwin recalled that the engineers and architects responsible for the great public works carried out at Paris in the first years of the nineteenth century constructed testing machines of as much as 100 tons capacity. In 1817 Peter Barlow published an essay on the strength of timber and other materials, recording tests made at Woolwich, whilst in 1825 Navier subjected all the members of a suspension bridge, which he was erecting at Paris, to a proof load of 10 tons per square inch.

All this constituted a great advance, and in some respects these early experimenters moved on more solid ground than many of their successors, who, carrying further the analysis of bridge and roof structures, developed certain theories as to the nature of the resistance of materials which have failed to fit in with experience. The early engineers worked on the secure basis of a factor of safety. It was left for another generation to develop the theory that the permissible stress on a structure is universally fixed by the elastic limit of a material, a view which is in direct contradiction with much every-day experience.

That a live load is much more dangerous than a dead load, was, the lecturer recalled, demonstrated by Fairbairn in 1861–62, and by Wöhler in 1871. The difference was long attributed to impact, and this theory still survives in certain bridge specifications. Its fallacy has been, however, conclusively demonstrated by M. Rabut in his exhaustive investigation into the actual stresses on the bridge structures of the Western of France Railway. The true theory of this phenomenon was, in fact, ready to hand, having been formulated in 1848 by James Thomson, an engineer whose insight into natural phenomena has rarely been paralleled. The theory, however, seems to have been almost totally ignored, until revived by Bauschinger thirty or forty years later, and but few connect Thomson's name with the elastic range of a material.

The Wöhler test, conducted as Wöhler did it, is quite possibly a reliable guide to the endurance of a material, but the length of time required renders it far from convenient in practice. Many attempts to abbreviate it have accordingly been made and not always with success. Thus Mr. Stead has noted that dangerous phosphoric steels may show up very well, indeed, in these pseudo-Wöhler tests—although their unreliability was quickly demonstrated in the Arnold machine.

Possibly the very ingenious alternating test machine of Mr. Stromeyer may be found a satisfactory substitute for the regular Wöhler test. Mr. Stromeyer makes use of the principle that if a bar is stretched within the elastic limit, it is cooled; whilst if this limit is exceeded, it is heated. He considers that the fatigue limit is reached when his

thermometer records a rise of 0·01 deg. C. The test can be made in one or two hours. Prof. Unwin notes that the fatigue limit thus obtained in bending exceeded that in torsion by 50 per cent. This observation, no doubt, must be connected with the nature of the resistance of materials to rupture, as to which somewhat discordant results have been recorded. This important point was only briefly touched on by the lecturer, who recalled that Guest in 1900 had demonstrated that in certain cases the controlling factor was the maximum shear stress developed, a view originally put forward, we believe, on theoretical grounds by the late Sir George Darwin. That this law is not universally applicable, however, has been repeatedly proved, one of the most striking demonstrations being that by Prof. P. Bridgeman, of Harvard, who has shown that cylinders burst by hydraulic pressure generally begin to fail at the external, and not at the internal circumference, as they should do, not merely by Guest's law, but by both the rival theories, which it was designed to supersede.

In the concluding section of his lecture Prof. Unwin gave some account of the principal testing machines and testing installations established in the different countries of the world. The general particulars as to the State establishments are fairly familiar. Prof. Unwin recalls that the German engineering laboratory of Gross Lichterfelde has a staff of 230 persons, the annual expenditure being £32,000. The four laboratory buildings of the Bureau of Standards at Washington with their accessories have cost £270,000, and the annual cost of maintenance is £120,000, while there is also an auxiliary laboratory at Pittsburg. Far more striking than these, however, are the data Prof. Unwin furnished as to the laboratories of the Pennsylvania Railroad. The buildings have cost £100,000. The physical laboratory contains a 500 ton and four smaller testing machines. In 1913 the annual cost of the laboratories amounted to £100,000. The wide gap between the value attached to scientific work by our own railway magnates and those of America could hardly be more strikingly demonstrated. We have failed to educate our "masters," implying by that term our shareholding classes, and the handicap, if maintained, may have exceedingly serious consequences to the nation.

Prof. Unwin mentioned but two large testing machines in this country, viz., the Kirkaldy machine of 400 tons capacity, and the 300-ton machine constructed by Messrs. Avery for the Birmingham University; there is, however, also a 350-ton Wicksteed machine at Cardiff. At Berlin there is one machine of 500 tons capacity, and another rated at 3,000 tons in compression and 1,500 tons in tension. In America there are numerous large mach ines, including the only "precision" large machines in the world. The latest of these is the Emery machine at the Bureau of Standards, which although of 600 tons capacity, can measure a stress of a single pound. For comparison, it may be recalled that the Board of Trade prescribe that a 1-ton weighing machine must be accurate within 8 oz., and normally as the machines are sent out by the makers, they will, under full load, turn with less than 4 oz. To calibrate the Bureau of Standards machines auxiliary gear weighing no less than 105 tons was provided. The largest machine in the States appears to be the Olsen machine at Pittsburg, which is of 5,000 tons capacity, and is claimed to be accurate within 1 per cent. It is of the vertical type, and will admit 65 ft. between its heads, which are 6 ft. square. It has been used for testing models of the chord members of the new Quebec Bridge.

The results obtained in ordinary tensile, compression, bending and torsion tests can (with certain reservations) be translated directly into the working stresses on structures. There are, however, certain other tests coming more and more into general use, of which the precise significance of their indications is much less clear. These tests, however, serve most effectively to control the quality of a material. Amongst them Prof. Unwin mentioned the Brinell hardness test, and the scleroscope test, both of which are proving of the utmost practical value, although opinions differ widely as to the precise physical meaning of the results observed. Another test which appears to be less popular than seemed probable a few years back is the notched-bar test. The usual objection made to this is that it is too drastic in character. Good serviceable material, it was asserted, often failed to pass the test, although its capacity for detecting really bad material has never been denied. In this connection the statement quoted by Dr. Unwin from M. Derihon when speaking at the International Congress at New York in 1912, would seem to show that the drastic character of the test is not a commercially insuperable obstacle to its practical use. M. Derihon stated that he had applied the test to an output of 80 tons to 100 tons of steel a month. At first 20 per cent. to 30 per cent. of the material failed to pass the test, but this led to such improvements in the heat treatment of the metal, that in 1911 the rate of rejection was reduced to 3 per cent.

At the conclusion of the lecture the President, Mr. Michael Longridge, paid a graceful and well-deserved tribute to Dr. Unwin's public spirit in acceding to the request of the Council that he should give the Sixth Thomas Hawkesley lecture. They had had, he said, some qualms of conscience in seeking to impose this burden on one who was already engaged up to nearly the limit of his strength on national duties, but the lecturer, after—under the conditions—a not unnatural hesitation, had finally yielded, and had not only prepared the lecture to which they had listened that evening, but had promised to deliver it also at the three provincial centres. In these days of crowded and inconvenient train services this undertaking involved no small sacrifice.

THE AERO ENGINE AND THE CAR ENGINE.

The relationship between the motor car and the aeroplane is a very direct one. Flight would have remained impossible to this day had not the motor car revolutionised our ideas as to possible limits of weight in prime movers, and it was also the motor car which was in the main responsible for the introduction into commercial engineering of the alloy steels which have so greatly facilitated the task of the designer. When the initial stages had been passed, however, the aero-engine began to develop on independent lines. The Gnome engine and its derivatives, for long so popular in the air services, had no parallel in automobile practice. In fact, the view became prevalent that the conditions of the two services differed so materially that the corresponding lines of engine development were more likely to diverge still more widely in the future than they had in the past. It was pointed out that the aeroplane engine had to work continuously at full output for long periods of time, a demand which the motor car engine was seldom called upon to meet. Flexibility in the matter of running steadily at widely different speeds was not demanded in the air services, whilst of high value in motor car practice. Many engineers, nevertheless, whilst admiring the ingenuity exhibited in the various designs of radial aeroplane engine, were reluctant to admit that the line of progress lay along a path so divergent from normal practice in other fields, and argued strongly that in the end a return would have to be made to the motor car type.

For long, however, the radial type of engine excelled its competitor in the prime essential of a smaller weight per effective horse-power developed. Figures published in the annual report for 1915 of the American Advisory Committee on Aeronautics showed that the weight of the lightest water-cooled engine for which data were accessible, a Benz engine, was 4.2 lb. per horse-power, whilst for the Gnome engine the corresponding figure was 2.9 lb. The latter engine consumed, however, .805 lb. of petrol and .253 lb. of lubricating oil per horse-power hour, a total of 1.058 lb. in all as against a total for the Benz engine of 0.514 lb. This handicap of excessive fuel and oil consumption became increasingly serious as the duration of flights extended, and this consideration caused special attention to be directed to the improvement of the water-cooled motor car type of aero engine. The result has been that the 12-cylinder Liberty engine in which is embodied, in straightforward mechanical fashion, the cream of the experience gained during the past four years, weighs less than half as much per horse-power as did the Benz engine of 1915. This recurrence to a normal type of design may well have important effects on motor car practice in the future.

This question of the reaction of the aeroplane on the motor car was discussed at some length in the able and interesting presidential address delivered last week by Mr. A. A. Remington to the Institution of Automobile Engineers. Mr. Remington pointed out that it is no longer true to say that the aero engine operates mostly at full load, since as a matter of fact the engine nowadays is seldom called on to develop the maximum horse-power of which it is capable. In the first place because it is commonly flying at such an altitude that the volume efficiency is much below the maximum; and secondly, the full power is seldom required save in climbing. The running conditions are therefore approximating more closely to those associated with the motor car, than was the case even as recently as two years ago. In spite of the light weight, moreover, the aero-engine is substantially more economical than the motor car engine, and in spite of the higher compression by which this additional economy is secured, it is certainly not less reliable. There should, therefore, be some valuable hints here for motor car designers. On the other hand, Mr. Remington doubts whether the aero engine will ever equal the car engine in silence and in smoothness of working over a considerable range of speed and torque. At present, of course, silencers are dispensed with, since their adoption necessarily reduces the output of the engine. Mr. C. E. Lacke, in a report to the American Advisory Board, has, however, expressed the opinion that the adoption of a silencer need not diminish the mean effective pressure by more than 2 lb. per square inch.

By applying the experience gained in the air, however, Mr. Remington anticipates that the power-weight ratio, the economy and cost of the car engine may be considerably bettered. Considerable changes in our past methods of factory organisation will, at the same time, be essential if we are to make the most of our experience during the past four years. He foresees, for example, a very large increase in the scientific staff employed by the leading firms. It is, he remarks, too much to expect that one man should be at once a fully qualified metallurgist, chemist, physicist and experimental engineer. The proposal to have a works physicist is novel, but Mr. Remington believes that the need for such an official has now become apparent. Certainly our best prospect for re-establishing our industries after the war will lie in a large increase in what the accountant humorously calls the "non-productive" services.

Firms who have been compelled by the authorities to abandon for war work their normal manufactures will, in Mr. Remington's view, not be entirely losers by the change. They have gained valuable experience, which they would have missed had they continued their accustomed routine. They have had to learn new methods of production, which in many cases have turned out to be most material improvements. The experience thus acquired may well prove a considerable asset, and may constitute at least a partial compensation for the interruption of the normal trade relationships of the firms affected.

NEW BRITISH AND KEY INDUSTRIES EXHIBITION.

On Monday, October 7, just a month after the closure of the British Scientific Products Exhibition, a new industrial exhibition was opened in the Central Hall, Westminster. In this instance the initiative and organisation are due to the Industrial Section of the Tariff Reform League, which bears the responsibility, and to Mr. Edward J. Duveen, Mr. Ben Dent, and Mr. Graham Anderson in particular. The invitation circular states that the exhibition has been sanctioned by the Ministry of Munitions and by the Board of Trade. Mr. Austen Chamberlain was to preside at the opening ceremony as President of the League. In his absence, owing to illness, a letter by Mr. Chamberlain was read by Mr. H. J. Mackinder, M.P., chairman of the League.

The political flavour, which the name of Tariff Reform League suggests, was not missing from Mr. Chamberlain's letter. The name chosen for the exhibition, New British and "Key" Industries Exhibition, is rather ambitious, and to single out tungsten as the key metal, as is done in the handbook, may turn metallurgists to further search for additions to iron that will give iron all the qualities desired for particular purposes. Tungsten is a very remarkable young metal; aluminium was considered so thirty years ago, and we live in the iron age still. In how far hair brushes, leather bags, picture frames, dolls and games can rank as key industries, we will not discuss. Instructive essays may certainly be written on the æsthetic and educational value of toys, but that is not our task. We are quite aware, moreover, that no branch of industry stands by itself.

The Exhibition is compact, and so far is housed in two halls on the ground floor of the building; the galleries upstairs were opened yesterday. Attention has been paid to pleasing display, many firms have impressive large stands, and when one leaves, one rather wonders how the 145 exhibitors, enumerated in the handbook, have found space. Nearly half of the exhibitors were represented at the recent exhibition at King's College; in most cases, however, the exhibits are of different kinds or differently grouped. The handbook, of 112 pages (sold at 1s.), which is well and conveniently arranged, does not contain much detailed information in addition to the general articles on the chief industries, the ramifications of which are duly explained with the aid of diagrams. No charge is made to visitors, nor has any charge been made to exhibitors for space. The exhibition is to be kept open every day from 11 to 8, till October 22, when it will be transferred to Manchester and to other centres; the hours and date, which are announced on a poster outside the hall, might have been mentioned in the handbook.

Metallurgy is to the front. On entering, the visitor faces Messrs. Hadfield's excellently arranged exhibits; part of these on the right will be familiar to visitors from the King's College exhibition; the alloys and Era and Hecla steel manufactures—crushers, check plates, liners for ball and tube mills, dredger pins, sprocket wheels, &c.—are new to these exhibitions. The variety of the alloys of iron with many metals, including tantalum, zirconium and sodium, of copper, cobalt, aluminium, &c., is very great. Some of these electric furnace products—used, though not prepared by Messrs. Hadfield—may be of possible rather than of actual use; the ferro-sodium, a greyish powder, may be utilised like an alkali-amalgam to diminish the energy of a reduction by sodium and to introduce the sodium in a convenient form. Some striking specimens of forgings demonstrate that "era" steel lends itself to artistic shaping like wrought iron. The compositions of the Hadfield steels are exemplified with the aid of glass jars of one quart capacity, containing the various constituents in approximate percentages. From these and the printed tables we see that galahad steel contains 0·3 per cent. of carbon, 0·13 per cent. of manganese and 13 per cent. of chromium; era steel, 1·25 per cent. of carbon and 12·5 per cent. of manganese; high-tensile hecla steel 0·3 per cent. of carbon, 0·15 per cent. of silicon, 0·5 per cent. of manganese, 0·7 per cent. of chromium and 3·5 per cent. of Ni; hecla high-speed steel 0·6 per cent. carbon, 1·1 per cent. manganese, 16 per cent. tungsten and 0·6 per cent. chromium. Sir Robert Hadfield also exhibits specimens of tensile and Izod and Frémont impact tests, and further, a model of the United Engineers' Society Building, of New York, 254 ft. high, to which he has frequently referred in discussions on the organisation of scientific bodies and publications.

If we notice the other chief iron and steel firms in alphabetical order—as far as not mentioned in connection with the King's College Exhibition—we find that Messrs. Edgar Allen & Co. show, in specimens and photographs, their manganese rail steels and steel castings of war-time interests, helmets, tank gears, chain links, bomb steel; further, circular saws for cold and hot metal, crushing rolls, cement mills, and shoes and dies for stamping mills, forged from pure steel &c.; one railway crossing shown had been bent cold to an arc under a tup of 25 cwt., and then dropped 60 times through a height of 30 ft. Messrs. Armstrong, Whitworth & Co. exhibit tools of carbon steel and of tungsten steel (18 per cent. of tungsten), dies and chasers, twist drills, reamers, relief cutters and circular saws; the latter are made of mild steel, and the special-steel teeth fit into peripheral pockets lined with carbon steel. The millionth-measuring machine also on view is the original machine of Sir Joseph Whitworth of 1855; it works with a gravity piece, which drops when one of the centres is slightly receded, measuring to a millionth of an inch; the gravity piece is also utilised in the Pratt & Whitney machines. Messrs. Thomas Firth & Sons show samples of bullet-proof manganese steel tested at ranges of 300 yards, and of non-magnetic manganese steels; further, tungsten (18 per cent.) steel, among which a shell-boring tool, magnetos (in conjunction with the British L. M. Ericsson Company, of Beeston), and nickel and nickel alloys, including the Firth-Brearley stainless knife steels. Messrs. Vickers utilise their central stand for demonstrating the testing of their magnetos under actual test conditions. Magnetos (6 mm. gap) for six- and eight-cylinder engines are sparking continuously, and an engine, run for the demonstration at 2,000 revolutions, sends a rapid succession of sparks up a slightly diverging spark gap of 10 mm., arranged like a lightning arrester of the horn type. The variable speed gear of the firm has been illustrated in our columns, and its new adaptation to steering gears will be described on another occasion. The new sewing machines of Messrs. Vickers are of the vibrating shuttle hand and treadle type. Among the tools we notice the high-power twist drills of vanadium steel and the quick-change chucks. Large photographs illustrate the making of guns; the firms already mentioned display similar photographs of works, guns in action, &c. Noteworthy in special tungsten steels are, in the first instance, the High-Speed Steel Alloys, Ltd., of Widnes, which manufacture tungsten from their mines in Burmah in works over there and here. On the stand of the firm a good many well-known firms of Sheffield and other localities exhibit their own specialities in this line; it should be noted that these firms are not enumerated in the handbook, and are, hence, not included in the 145 exhibitors we counted. The firm of Messrs. Alfred Herbert, of Coventry, classed under tungsten in the handbook, practically confines itself to self-opening die heads for cutting screws of all threads, made in seven sizes, from $\frac{1}{4}$ in. up to 3 in. Messrs. Duram, Ltd., exemplify the reduction of tungsten and molybdenum ores.

As regards various electric furnace products and alloys, Messrs. Thermit (Nobel's Explosive Company, of Glasgow) stand foremost with their beautiful specimens of carbon-free metals and alloys used in the production of tool steels, brass, bronze, cupro-nickel, &c.; their fine specimens of thermit-welds, big steel bars cut through to demonstrate the perfection of the weld, will likewise attract attention. The Thermo-Electric Ore Production Corporation, of 244, High Holborn and Luton, reduce tungsten, molybdenum, chromium and other ores obtained from their mines in Burmah and Australia, and from other mines; their ferro-vanadium is reduced from mottramite, which is first treated for vanadic oxide and then smelted electrically. The ferro-zirconium is utilised as a refractory, and as a 30 per cent. zirconium alloy also for hardening iron. Of special interest for magnetos and aircraft are the permanent magnets of Messrs. J. Neill & Co. and Messrs. J. J. Saville & Co., both of Sheffield, and the enamelled wire from the London Electric Wire Company, and Smiths, Ltd., Playhouse Yard, E.C.1.

Aluminium is well represented by the British Aluminium Co., which exhibits the ores, the intermediary and by-products, ingot sheets, bars, wire, powder, alloys, girders, tubes, aluminium field coils for electric apparatus, and aluminium sulphate and alumino-ferric for water purification, &c. Zinc is not conspicuous at the Exhibition. Tin ores are exhibited by several firms. The East Pool & Agar Company, of Carn Brea, Cornwall, is also stated to show some products, the concentrates, the dressed wolfram, arsenic soot, &c., and a mine model in glass; but we have not yet found this exhibit, nor the stand of the British De-Tinning Company, Morgan L. Jones and Co., of 47, Victoria-street, S.W. Lead and antimony are exhibited by one firm only, Messrs. Cookson and Sons, of Newcastle-upon-Tyne. The lead is either pure and soft, for the manufacture of sheet lead and lead pipes and of lead oxides, or hard, containing up to 15 per cent. of antimony, for the manufacture of bullets and shrapnel bullets and of accumulator grids; the lead peroxide electrodes require pure lead, of course. The firm made a fine display of their lead oxides (red and orange) at the British Scientific Products Exhibition. The antimony of the firm has a purity of 99 per cent; the exhibits include antimony ores, oxides and compounds. We have not seen accumulator batteries anywhere in the exhibition.

We will return to the subject when the Exhibition is more complete.

THE RHENISH WESTPHALIAN COAL SYNDICATE.

The Rhenish-Westphalian Coal Syndicate, the largest industrial-commercial combine in Europe, came into existence on February 16, 1893, fifty, or to be exact, 49 years after the collapse of the once powerful English coal ring, and on February 19 the syndicate came into operation. Much labour and many minor attempts had, however, preceded this consummation, for however beneficial syndicates and kartels have proved themselves to be in Germany, their ultimate formation has generally proved a protracted and troublesome process.

Towards the end of the seventies that craving for system and organisation which is now one of the most pronounced and remarkable features of the German industry, began to manifest itself and to assume more definite shape, and in the year 1877 it began to bear fruit as far as the coal mining industry was concerned. Unsatisfactory prices and a sluggish sale invited fresh efforts, and in the year 1877 23 coal mines in the Bochum and Gelsenkirchen districts formed a Westphalian coal export union, principally designed to oust British coal from its position in the North Sea ports and also to widen the market for West German coal in other directions. This first move, however, did not prove of much avail, notwithstanding certain facilities granted by the State in the matter of an exceptional tariff. Equally futile was an attempt made the same year to control and limit the production of coal so as to improve prices. Coal owners were only feeling their way, and the arrangement did not provide for fines, should any of its members violate the agreement. Within the following ten years there were several successive fresh output-regulating conventions, but they were not of much use and were of but short duration. Fines had certainly been introduced for excessive production, but they were too light to prove of much effect, some mines finding it worth their while to pay the fine and please themselves as regards output. Most of these more or less fumbling attempts lacked the broader basis upon which many of the leading German syndicates now stand, and were simply private arrangements between employers anxious to protect their own individual interests as regards sale and prices. Other endeavours at price conventions bore no better fruit, and neither did the attempt to regulate production undertaken in the year 1887 through the medium of the common mining funds. A court of law decided that this fund was not entitled to draw an additional sum from such mines as did not observe the limitation of production agreed upon.

In spite of all these failures the conviction prevailed amongst the more far-seeing members of the coal-mining industry, that an organisation was necessary, and it also became clear to them that the only solution was a joint sale of the mining products coupled with a really effective regulation of the output. The whole question had to be dealt with in a broad spirit to which individual greed and gain would have to subordinate itself. The full attainment of this ideal, however, could not be reached at once, and as it was found impossible to gather all the mines of the large district into one fold all at once, several smaller selling unions came into existence about the year 1890, under somewhat

different forms, but all more or less directly intended to regulate production and price. Half a dozen of these were formed as regular limited companies, which style of organisation was destined to survive in the Rhenish-Westphalian Coal Syndicate. These various selling concerns worked fairly satisfactorily as far as their own immediate members were concerned, but competition between the respective bodies could not be prevented.

It was this very fact which paved the way for the formation of the large Rhenish-Westphalian Coal Syndicate. This, like its immediate small forerunners, was inaugurated as an ordinary limited company, with the extremely modest capital, considering the magnitude and scope of the work in store for it, of 900,000 marks. It was domiciled at first at Bochum, its headquarters being subsequently transferred to Essen. There are 3,000 shares of 300 marks each, registered by name, and their transfer to another person is subject to the sanction of the company, and must be approved of by the controlling board and by a general meeting.

Simultaneous with the formation of the actual company, about which there is nothing remarkable, was the conclusion of an agreement between it and the owners of coal mines in the Ruhr district, and an agreement among these owners mutually. The object of this agreement was stated thus: To do away with undesirable competition between the mines, and as far as possible to arrive at fixed agreements with other mine owners and unions, where there was any likelihood of competition as regarded the share of the total sale as well as regarded prices and conditions of delivery. This latter clause, it will be seen, left the road open for still more comprehensive arrangements. Each coal owner undertook to take the number of shares which was proportionate to his production, and in this way all outside influence was avoided.

The agreement, which it will be understood is the backbone of the syndicate provided for several special authoritative bodies, namely:—

1. The meetings of the mine owners, at which, to carry a resolution, three-fourths of all votes must be present. Only the legitimate representative of each mine has access to these meetings, or, should he be prevented, an official of the mine provided with proper credentials. Representation by a third person is not allowed. The meetings of the mine owners are called, when the council deems such step necessary, or when mine owners controlling at least one-fifth of the aggregate votes communicate to the board their wish in writing to this effect.

Upon the meeting of mine owners rests:—

(*a*) The appointment of the council.

(*b*) The election of members of the commission for fixing the fundamental allotment figures.

(*c*) The decision as to possible reductions in the production, for a shorter or a longer time, as proposed by the board.

(*d*) The fixing of the fines and the compensation to be paid respectively for excess or deficiency in sale.

(*e*) Decisions as to the acceptance of new members.

(*f*) The fixing of the number of shares to be held by the different members.

The mine owners' meetings consequently do not fix the price of the different products, nor, finally, the allotment figures.

2. The council is an advisory body supplementary to the board, and in some cases acts as a kind of final court. Each mine owner, or group of mine owners, has the right to appoint a member of the council (and a substitute) for each 1,000,000 tons of allotted production.

The council fixes the general principles as regards prices, and also the standards for quality, and in accordance with these the board settles selling prices and selling conditions. The mine owners themselves have no voice in this matter which, it will be seen, rests jointly with the council and the board. The council thus confines itself to the more general, fundamental issues, by which, however, the board must abide. Should the prices not conform to their decisions, the council can raise objections. With the council rests further the final decision in disputes about allotment of sale, in cases of mines failing to comply with their conditions of delivery, in cases of compensation, &c. Finally, the council fixes the amount to be deducted from the monthly accounts, when sums have to be withheld for expenses or other reasons.

3. The commission for fixing the allotment figures comprises four members: That is, two experts, one merchant and one a member of the board of the company. Care has been taken that no shareholder or official of the mine in question, nor of the council, has the right to influence the membership of this commission.

The joint sale comprises the entire production of coal, coke and briquettes, excluding the quantities needed for use at the mines and that supplied to officials and employees, as well as fuel given in charity.

After March 1, 1893, the mines were required to hand all orders and all direct inquiries to the syndicate, to which their execution was transferred.

The agreement gives the board of the syndicate the right to buy and sell coal, coke and briquettes from outside mines, an arrangement no doubt made to reduce the competition from those not in the agreement.

A very important factor in the working of the syndicate is the regulation of the individual outputs. The production during either of the preceding years, 1891 and 1892, at the option of the mine owner, was taken as a basis. If there had been any stoppage of work, that was allowed for. At the present time new shafts, or such as have not yet reached their normal output, are allowed to work 400 tons per day. The allotment commission decides as to which shafts have not reached their full output. When a mine owner desires a higher quantity of the joint sale, he must apply six months in advance to the Westphalian coal syndicate. As regards the first allotment, a proposal for an increase can be made there and then when signing the agreement. If, according to the opinion of the board, the increase of production cannot be allowed on account of the prevailing conditions of sale, without a general reduction of the sale allotments, then the decision is referred to the allotment commission. In arriving at its decision the commission must not only consider the technical possibilities of an increased production, but also the general position of the mine as well as the state of the coal market. Appeal against this decision is allowed for a fortnight both to the mine owner and to the board of the coal syndicate, this appeal to be addressed to the council, with whom rests the final decision. The allotment takes effect from a given date. The mine owner, however, is bound to deliver the quantity in question, unless he applies to the board of the syndicate for a reduction, which cannot be refused. Any one desiring to increase his output or to bring further plant into operation, has to inform the board, three months in advance, of the daily production in question and is then obliged to deliver. Those who do not deliver the specified amount may be fined by the board during the first year at the rate of 2 marks per ton of deficiency. In each successive year the fine is fixed by the general meeting of the mine owners.

In case of disputes the case is first adjudicated by the commission, but there is an appeal to the council. Should the state of the market require a reduction of the aggregate production, a proportionate decrease in the output is determined by a resolution at a general meeting of the mine owners. In case such reduction cannot be established uniformly on account of existing contracts or owing to quality of the coal, the mines which have allotted a larger sale quantity have to pay an amount on the excess quantity to the Rhenish-Westphalian Coal Syndicate, whilst those mines whose sale remains below the allotment figures obtain compensation for the shortage from the coal syndicate. This also holds good when a reduction of the output has not been decided upon. Both sums to be paid and the compensation to be awarded have to be fixed every year at the first meeting of the mine owners.

As regards the question of price, the Rhenish-Westphalian Coal Syndicate holds the position of actual buyers in relation to the mine owners. In the local area, where no outside competition is met, the actual price obtained is to be credited to the mine (subject to a deduction mentioned below). In sales, however, which have to meet a competition from mines outside the Rhenish-Westphalian area, and for which exceptional prices must be accepted, compensation according to the merits of the case and as fixed by the board and approved by the council, is paid to the mine which has delivered the coal in question, not exceeding the difference between the price obtained and the average of the business transacted within the local area. This, of course, is also subject to the deduction mentioned.

Each mine owner is responsible for the good and proper delivery of the quantity and the quality of coal sold to the Rhenish-Westphalian Coal Syndicate; he must bear all the expense and cost arising from inferior or inadequate quality or other shortcomings. The decision whether a default of this nature has taken place, rests with the board of the Rhenish-Westphalian Coal Syndicate, which has to look carefully into each case. Appeal, however, can be made to the council, which finally disposes of the case.

The mine owners hand in monthly accounts of coal, coke and briquettes delivered, which the syndicate pays for before the 20th of the month following after delivery. So as to cover all business expenses, the compensations mentioned above and a possible deficit, a deduction is made from the monthly accounts, the amount of which is fixed by the council on the recommendation of the board.

In cases of contracts of delivery over more than one year, the approval of the mine in question has to be obtained.

Should any of the contracting mine owners, contrary to the agreements, sell, direct or through intermediaries (so as to circumvent the syndicate), he has, on detection, to pay a fine of 50 marks per ton.

As regards other defaults in connection with the agreement, each of the mine owners undertakes to pay a fine of 1,000 marks for each case. The fine is decreed by the council and appeal to the meeting of mine owners can take place within a fortnight, who may reduce the fine to 100 marks in each case. In cases of refusal to pay, the syndicate is entitled to deduct the amount of the fine from the credit account of the mine in question.

The agreement came into force on March 1, 1893, and was concluded for five years, to continue for another five years unless one or more of the contracting parties gave notice of cessation.

The syndicate was joined by about 100 mines (98 if we mistake not), representing about 94 per cent. of the entire coal production of the Rhenish-Westphalian district and an annual production of some 35,000,000 tons. Thirty mining concerns were left out of the syndicate, seven of them, with an output of 3,758,000 tons, belonging to iron works which themselves used about two-thirds of the production, and 23 coal mines proper with an annual output of about 1,057,000 tons.

The Rhenish-Westphalian Coal Syndicate may be said in every respect to have answered the expectations with which it was started, or rather it has far exceeded these expectations. Not that no errors were committed during the first few years of its existence, but it could scarcely be otherwise with a hostile undertaking of this magnitude, which had to encounter a more or less demoralised market and more than one adverse condition. Unfavourable criticism from various sides was for some time freely directed against it, but by degrees its detractors grew silent and its dissolution would now be looked upon not only as an industrial and financial, but almost as a national calamity, owing to the closer insight gradually obtained not only by those more directly concerned in its working, but also by the public generally. This also applies to the Government and the legislature; as far as the latter is concerned all parties are agreed that the Prussian State has the greatest interest in the maintenance and renewal of the coal syndicate. Some four years ago the Minister for Commerce, Herr Sydow, stated in the Prussian Diet "that a collapse of the coal syndicate would give rise to a struggle and lead to conditions which not only would involve the question of profits, as far as the mining industry was concerned, but also have a most harmful effect upon employment and wages,

and in this way lead to very serious industrial and social upheavals. The transitory advantage, which the collapse of prices might mean to the consumer of coal would be out of all proportion to the harmful consequences."

Properly to gauge the vast influence exercised by the Rhenish-Westphalian Coal Syndicate one should consider not only the fact that the production of the district under its control has been about tripled during its existence, and that the market for German coal has been widened so as to comprise the most distant portions of the world, but also the state in which the coal-mining industry was found at its start. Apart from a few short periods of exceptional activity with pronounced high prices, the Westphalian coal-mining industry, up to the time of the formation of the syndicate, held such an inferior position as regards returns as compared with other industries, more especially the iron industry, that its position has been described as that of a "maid servant." Except in a couple of boom years most of the coal mines gave no returns at all, and a number even worked with a distinct heavy loss. This unsatisfactory state of affairs prevailed in spite of a steady and ever-increasing consumption, principally as a result of keen competition. Of suiting the production to the requirements of the market there was no question. The absence of profits, not to mention the frequent losses, which were the rule in many cases, necessitated a most lamentable degree of economy, which tended to lower wages. Prices for coal also moved downward, as the production increased.

The state of affairs prior to the formation of the coal syndicate is illustrated by the fact that during the period 1873–90 the Ruhr district coal industry was only able to earn an average of 4½ per cent. on the capital invested in it, and this with an average of only 1½ per cent. writings-off and ¾ per cent. added to the reserve fund, whilst experts insisted upon respectively 3 per cent. and 1 per cent. as a sound basis; had this been complied with the 4½ per cent. would have had to be reduced to 3 per cent.

The following table shows how the cost of production increased and the immediate increase in interest on the likewise increased capital, which followed in the wake of the formation of the coal syndicate :—

—	Production.	Costs in Marks per Ton.	Surplus in Marks per Ton.	Capital Invested in Marks per Ton.	Interest on Capital Invested.
	Tons.				p. c.
1878	11,400,000	4·94	0·35	22	1·6
1885	19,100,000	4·81	0·54	19	2·8
1894	32,400,000	6·38	0·84	20	4·2

The coal syndicate succeeded in consolidating and raising the prices very materially, for four different kinds of coal, as under :—

	Marks.	Marks.	Marks.	Marks.
1893 ...	6·00	7·00	8·00	9·50
1907 ...	10·00	11·00	11·75	12·50

and the dividend of coal shares had in the meantime for several years reached an average of between 10 per cent. and 11 per cent., and in one case even exceeded 14 per cent. In other words the prices for coal had gradually risen (with some intervening years of retrogression, though never to the unprofitable figure of the ante-syndicate average) from about 33 per cent to close upon 70 per cent., whilst the interest earned on the capital had advanced from some 2–3 per cent. to 10 per cent. and more. Wages, too, increased, but not nearly so much as the price of coal; it will be found always to be the case, at least so far as Germany is concerned, and up to a few years ago, that with rising prices the wage percentage of the price recedes. In other words, although, unquestioningly, the coal syndicate has in various ways benefited the men, the rise in prices, which it helped to bring about, has benefited the masters more than the men.

It is not necessary to enlarge upon the strenuous and continuous work involved in the routine of the coal syndicate. The fixing of the prices is perhaps the most difficult task, inasmuch as regard has to be shown to the position of the iron market; lest it should be unduly affected by an alteration in the price for fuel. A reduction in the quotation for coke, for instance, even if justifiable or even advisable from the syndicate's view as a seller of the commodity, and looked for by others, might unfavourably affect the iron market, which often is very susceptible. The coal syndicate, in fixing quotations for six months, has occasionally had the charge laid at its door that it fixed its prices rather too early and for too long a time, and deviations from this rule, when for instance quotations instead of for six months have only been fixed for three, have shown that the syndicate, in spite of its commanding position, is anxious to meet the views of its *clientele*. Criticism has, however, subsided more and more of late years.

As already mentioned, the production of coal under the auspices of the coal syndicate increased in a rapid and continuous manner. During the first twenty years the production was as under :—

	Tons.
1893	33,350,230
1894	35,044,225
1895	35,317,730
1896	38,916,112
1897	42,195,352
1898	44,865,535
1899	78,024,014
1900	52,080,898
1901	50,411,926
1902	48,609,645
1903	57,822,837
1904	67,255,901
1905	65,382,522
1906	76,631,431
1907	80,155,994
1908	81,920,537
1909	80,828,393
1910	83,628,550
1911	86,904,550
1912	93,797,666

During the same period the sale of coke rose from 4,196,917 tons to 13,375,831 tons, and that of briquettes from 694,025 tons to 4,006,421 tons.

The production of coal in Upper Silesia and of the Crown mines in the Saar district has also increased materially during the period referred to, but not at the same rate as that of the district controlled by the coal syndicate, the output at the beginning and end of the two decades being respectively 17,100,000 tons and 40,000,000 tons and 5,900,000 tons and 12,500,000 tons.

As regards the different branches of industries and other consumers, to which the sales of coal, coke and briquettes by the Rhenish-Westphalian Coal Syndicate are effected, the following table gives the relative percentage for home consumption :

Iron and other metal works, steel and machine manufactories, instruments and apparatus works	Per Cent. 42·58
Domestic purposes	12·35
Rail and tramways	10·87
Production of coal, coke and briquettes	7·00
Shipping of all descriptions	5·91
Stone and earth industry	4·38
Gas works	3·33
Chemical industry	3·03
Textile industry	2·82
Electrical industry	1·58
Paper industry, &c.	1·32

All other industrial branches are below 1 per cent.

As regards the export business of the coal syndicate, this has also increased very materially and doubled itself during the last decade. For the year 1912 the figures were :—

	Tons.
Coal	14,004,000
Coke	4,520,000
Briquettes	1,686,000

Of the aggregate export, Holland received close upon 30 per cent., France 25·2 per cent., and Belgium 22·4 per cent. The oversea export shows a rapid development, having been about tripled in five years, and for the year 1912 amounting to 3,091,275 tons.

MANGANESE FROM MEXICO.—It is stated by mining men from Mexico, says *The Iron Trade Review*, Cleveland, Ohio, that there is much activity in developing manganese claims in that country, particularly in the State of Chihuahua. At some of these properties considerable quantities of ore have been accumulated, and shipments will be made to the United States as soon as the transportation and exporting arrangements can be made. For a long time it has been known that extensive beds of manganese ore existed in Chihuahua, and claims are made that the present large demand and high price have caused them to become of much commercial importance.

NOTE.

MINERAL RESOURCES OF RHODESIA.

IN the report for 1918 issued by the Rhodesian Munitions and Resources Committee, a committee which was formed in November, 1915, as the result of a request from the Imperial Minister of Munitions, interesting information is given on the various resources of the Rhodesian Government. From this report we extract the following items of interest on several minerals. The Selukwe deposits of chromite are very extensive and have excellent working facilities. The mineral is also abundant in the "Great Dyke" at Makwiro, close to the railway line, and this locality is very favourably situated for exporting ore, but the percentage of chrome is low and cannot be brought up, by even the closest picking, to a grade like that of the Selukwe chromite. The deposits of the much more ancient and highly altered serpentines and talc schists of the metamorphic areas are more likely to yield workable bodies of ore. In regard to manganese, as far as at present known, ores of this metal are very sparsely distributed throughout Rhodesia. Nickel is known to occur in a number of widely separated Rhodesian localities, but only in small quantities. It may be, however, that the search for asbestos, which is being so vigorously prosecuted all over the country, will have as one of its results the discovery of workable ores of nickel. The ores of tungsten are very widely distributed throughout Rhodesia and occur in some quantity at several different localities. Both wolfram and scheelite have figured among the Rhodesian exports for the past 12 years. The ores of vanadium have only so far been recorded from the Broken Hill Mine, where descloizite (vanadate of lead and zinc) occurs in crystalline masses, and vanadinite (vanadate of lead) chiefly as a stalagmitic crust on other minerals. Molybdenite is known to occur at many Rhodesian localities, especially in the neighbourhood of Bindura, in the Hartley district, and near Bulawayo, usually in quartz reefs in granite country or near granite contacts. Some work has been done on the occurrence of tantalite noted in the Victoria district. Zircon is a common accessory mineral of the igneous rocks in Rhodesia. So far, however, it has not been found anywhere concentrated in notable quantities, though it occurs in syenite, pegmatite, &c., at Hillside, near Bulawayo. The production of chrysotile asbestos, which first received attention in 1907, has now grown to considerable proportions, and promises to extend still further as time goes on. Magnesite is known to exist in many Rhodesian localities in the form of veins and nodules amongst the serpentines of the metamorphic areas. It is often very pure, but in no case the size of deposits has been closely investigated, owing to the price holding out little prospect of successful working. Early in December, 1917, a specimen of dark brown mineral resembling zinc blende was found to be triplite, fluor-phosphate of manganese and iron, a mineral easily soluble in hydrochloride acid, readily fusible and normally containing from 30 per cent. to 35 per cent. of phosphorous pentoxide, P_2O_5. Since the deposit in which the mineral occurs may be mined for the recovery of bismuth ore, there appears to be no reason why the triplite should not be recovered also as a by-product. In view of the serious shortage of phosphatic fertilisers in South Africa, it seemed worth while to ascertain if large quantities of the mineral might be won by mining, and whether it might be useful as a fertiliser. Inquiries are accordingly being made and research and practical trials conducted.

THE USE OF ACETYLENE FOR RAIL CUTTING.—According to *The Railway Review* there was recently much trouble from the creeping of rails on a trestle belonging to the Chicago, Milwaukee and St. Paul Railway. The result was that the track kinked out of alignment. The usual remedy was to replace certain rails by shorter lengths. This was difficult owing to the frequency of the service, which only allowed of 4 minutes for the complete operation. The difficulty was further increased by the fact that the 'creep" had at times jammed rail ends so tightly together that it was not easy to remove the rail even after the spikes had been pulled. It was decided accordingly to shorten the rails *in situ* by cutting out pieces by means of the acetylene torch. With the torch it was found the rail could be cut clean across in 1 minute. The acetylene torch was also used for cutting fresh bolt-holes, an operation effected in 50 seconds.

LITERATURE.

Aircraft Mechanics' Hand-Book: A Collection of Facts and Suggestions from Factory and Flying Field to Assist in Caring for Modern Aircraft. Illustrated. By Fred. H. Colvin, A.S.M.E. London: Hill Publishing Company, Limited. [Price 3 dols., post free.]

The sub-title is the more correct indication of the contents of this book. It is of considerable value and convenience for the excellent selection of extracts from the publications of the Royal Flying Corps, Wing-Commander J. W. Seddon, Captain Lagrange (of the French Air Service), and the technical information issued by engine-makers, including the Curtiss, Hall-Scott, Sturtevant, Thomas-Morse, Gnome, and Hispano-Suiza. The author was allowed to give only limited information about the U.S.A. standard or "Liberty" engine, which, he informs us, is designed chiefly by Mr. Vincent, of the Packard Motor Company, and Mr. Hall, of the Hall-Scott Company. There is no radical change, Mr. Colvin states, in the engine design, the modifications made being almost entirely to facilitate rapid standardised manufacture. The fixed cylinder type is adopted, and the cylinder is of uniform size for all sizes of engine. The cylinders are combined in sets of 4, 6, 8 and 12 on one engine base, and develop about 30 h.p. per cylinder. The cylinders are made from hollow steel forgings, with water-jackets stamped from sheet metal and welded on. The valve cages are also made separately and welded on. The total weight is about 2 lb. per horse power. It would seem to follow that a four-cylinder Liberty engine, 120 h.p., might take the place of a Clerget engine of the same power with nine rotating cylinders. The Clerget is extensively and successfully used on single-seater fighting scouts, carrying one and even two machine guns. The article or extract, written by Professor Charles E. Lucke, states that "the air-cooled motor has entirely failed in comparison with the water-cooled motor," and that "fixed cylinders have prevailed over rotating cylinders." In general practice, the air cooling and rotation of cylinders are combined in the same engine and in the engine used for the smallest and fastest machine—so that the two features must be considered together. The French engineers, who developed the Gnome and Clerget types, are the last to require to be told that the fixed water-cooled cylinder makes the best engine. But, the problem is, or was, to make a small engine. The Gnome type is far from being superseded (it is still being made in America for American planes); but even when superseded, it should not be referred to as a failure. It must always remain one of the greatest mechanical successes for its time and conditions.

A table of 23 American types of engines shows three Gnome and gyro types of 90 h.p. and 100 h.p., in which the weight per h.p. is 2·7 and 2·8 lb., while the fixed types are 50 per cent. to 75 per cent. heavier. The law based on weight of engine plus weight of fuel, oil and water, shows the superiority of the fixed type, but not until a point far above 100 h.p. is reached.

The book also contains a considerable amount of information in the form of instructions to inspectors and conditions required from makers, and the specification for the U.S.A. military training machine. There is also a very complete account of the Canadian training camp and training methods at Borden, Ontario, with some excellent suggestions by Roger Jannus, an instructor at the camp.

The undoubted value of the book as a compilation of varied aircraft information does not, however, make it an "Aircraft Mechanics' Handbook." The title rather misleads the practical man, who will expect concise, well-arranged information of a practical kind, and, therefore, of limited scope. It also rather misleads the designer and engineer who may not expect to find so much theoretical discussion and general technical data in a mechanics' hand-book. One defect in the style is the interminable repetition of the "you must be careful," and "this is of great importance" manner of addressing the mechanic. It is a mistake to "write down" to the mechanic; he is generally intelligent and careful, and what he lacks in these matters he will not learn from too frequent scolding. The chapter on instruments is, unlike the rest of the book, rather abrupt. It properly refrains from describing the construction in detail, but a little more should be said of the care of instruments and the detection of faults.

The chapter on definitions of terms indicates the technical rather than the practical hand. "To splice" is not properly defined as "to join two or more parts together"; splicing is essentially intercoiling the strands. The definition of a cotter pin describes a split pin, whereas a cotter pin is essentially a wedge. The definition of turnbuckle, the term now used for strainer, misses the essential feature; viz., that the screws are right and left-handed. Common names are as important as technical or scientific terms, and we regret to see them used carelessly. There is no attempt to give a list or description of mechanics' tools. It is quite odd to find in the index "Tools for inspectors," but none for the mechanic, for whom the book is written. These criticisms are offered to suggest points on which future editions might be improved. A really well-conceived and written handbook for aircraft mechanics would be a valuable work. The book is welcome, and will be useful to all engaged in aircraft work. We are pleased to see airplane used throughout in preference to aeroplane.

Carburation in Theory and Practice, including a criticism of Carburettor Development. A manual of reference for automobile engineers and owners. By Robert W. A. Brewer. Second edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 12*s.* 6*d.* net.]

This is the second edition of a work which appeared some time ago when motor cars were seen more frequently on the roads and the industry was more encouraged than at present. The appearance of a new edition may indicate that restriction on locomotion has not destroyed interest in motor car construction. The object of the treatise is to convey information on the properties and use of various liquid fuels and to suggest the means for getting the best results, so far at least as the process of carburation is concerned. A somewhat narrow significance is given to the term "carburation." It is defined as "the art of mechanically mixing or blending a liquid fuel with a certain amount of air." The object to be attained is the division of the fuel into its finest possible particles, and to surround each fuel particle with an appropriate quantity of air, so as to form as far as possible a homogeneous mixture and to assure complete combustion. The definition is apparently contrived so as to exclude the mechanics of explosion, involving the rate of propagation of the flame, the effects of compression and the composition of the gaseous exhaust. These consequences of carburation are alluded to, but not discussed exhaustively.

It will be seen, therefore, that only a small, but essential, part of the entire mechanism of the motor comes under review. The author tells us, however, that no part of an automobile has undergone more useful development with happier results. To its gradual improvements are traced the great range of speeds possible in engine rotation, the reduction of petrol consumption, more perfect combustion, the prevention of overheating and greater ease in starting. The author is himself the inventor of a well-known and successful form of carburettor, and it is possible that the study he has given to the working parts, the many experiments he has made, and the practical difficulties he has overcome, have led him to underrate the work of pure science and the results that have emanated from the laboratory. The investigations of Callendar and Hopkinson have been most fruitful. Professor Dixon's work on the ignition temperature of gases, as Dr. Watson's on the nature of exhaust gases, have been illuminating. Dugald Clerk and Dalby are names of inspiration in the history of the growth of internal combustion machines of all kinds, and though these names, or most of them, occur in these pages, the author's attention is so centred on mechanical construction, that we fear a reader would fail to attach the proper importance to the informing character of their work and the influence it has had on motor development.

The work is divided into two parts. The former is mainly theoretical, dealing with vaporisation, evaporation and combustion, under the conditions imposed by motor construction. The flow of liquid fuel through small orifices, circular and ring-shaped, is also considered. The second part is devoted to the description of carburettors that are on the market or in use. Whether the list is complete we cannot say, but it is certainly long, and it is safe to assert that no general type is omitted. Mr. Brewer's account of his own contribution to carburettor design is very interesting. He set out to design an orifice, which would combine the characteristics of a circular hole and an annulus, that is to say a composite orifice, that would avoid the defects of either and possess advantages peculiar to itself. This description enables one to trace the successive steps that led to the exclusion of certain forms and the adoption of others. This reasoning, as is known, led to the selection of a modulating pin hanging in a vertical position and so connected with the orifice that it is not liable to be displaced under any set of conditions. There is no necessity to mention all the precautions taken to ensure success, and we trust that in its final form it possesses all the advantages claimed for it. One would like to know, since it would throw light on the process of invention, whether any material modification had been found necessary. The second edition does not indicate any, but a prefatory note explains that a package of manuscript notes was sunk in transit, presumably by enemy action, and it has not been possible to replace the material completely. Some valuable information has been lost, and we offer our sympathy to the author who has had to contend with this misfortune.

In these days of shortage of motor spirit it is natural to inquire what the latest edition has to say on the substitution of coal gas. We must confess to some little disappointment. The few remarks vouchsafed in a separate appendix apply apparently to stationary engines, and nothing is said of the alteration in mechanical fittings that would best meet the changes from petrol to gas. We are told that gas, whose molecular subdivision is great as compared with that of a sprayed liquid, has an advantage over a motor spirit, by reason of the greater homogeneity of the mixture, but the effect of the substitution mechanically and economically is not fully worked out. The statement is made that with gas at 2*s.* 1*d.* per thousand cubic feet and crude petrol at 6*d.* a gallon, the saving in the fuel had been over 33 per cent., and under certain conditions even more favourable economics had been effected. The date of this experiment is not given, but the prices quoted suggest halcyon days that have long past.

Gas is the only substitute discussed. The possibilities of alcohol, though referred to in some of the tables, are not considered, either as a temporary alternative or as a permanent competitor against petrol. Similarly with benzol, absorbed now by the Ministry of Munitions, but the time must come when immense quantities will be released, available for use in internal combustion motors. But apparently the author does not consider feasible the adoption of a fuel unallied to petrol. It is admitted that the use of an alternative fuel involves no special difficulty, but "so long as the source of the substitute is the same as that of petroleum spirit and so long as the same groups of financiers control the substitute as the present fuel, difficulty and doubt will always arise as to the practicability of adopting that substitute with any financial saving." But petroleum spirit does not enjoy the unquestioned pre-eminence it once attained, or the reputation formerly possessed. An American authority has raised the charge of deterioration in the following terms. "The fuel supplied to a motor cannot be used efficiently except in the vapour form, and the same economic causes that have increased the price of fuel have led to such changes of its nature, that the whole of it does not evaporate under ordinary conditions, and the volatile portion will change perceptibly during the various conditions of average driving." This is strictly true. The prospective shortage of supplies of mineral oils, and the contingent high price of motor spirit, furnish very good reasons for the preparation of alcohol from waste or from unutilized raw materials, and for the examination of problems connected with denaturing.

There are very evident difficulties to be overcome in the use of alcohol, but there are also advantages. It can be more easily and safely stored, and moreover, since the compression ratio can be considerably increased, it could probably be employed with some gain in thermal economy. At present it is a more expensive fuel.

BOOKS RECEIVED.

Coast Erosion and Protection. By ERNEST R. MATTHEWS, Assoc.M.Inst.C.E. Second edition, enlarged. London: Charles Griffin and Co., Limited. [Price 12*s.* 6*d.* net.]

Present-Day Applications of Psychology with Special Reference to Industry, Education and Nervous Breakdowns. By CHARLES S. MYERS, M.A., M.D., Sc.D., F.R.S. London: Methuen and Co., Limited. [Price 1*s.* net.]

Ship Stability and Trim. By PERCY A. HILLHOUSE, B.Sc., M.I.N.A. Portsmouth: Gieves Publishing Company, Limited; London: John Hogg.

Proceedings of the Incorporated Municipal Electrical Association. 1918. London: Wyman and Sons, Limited. [Price 5*s.*]

Minutes of Proceedings of the Engineering Association of New South Wales. Vol. XXXII. Edited by J. MCNAMARA, Honorary Secretary. Sydney: Published by the Association.

A Small Book on Electric Motors for Continuous and Alternating Currents. By W. PERREN MAYCOCK, M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

Magnetism and Electricity for Home Study. By H. E. PENROSE. London: The Wireless Press, Limited. [Price 5*s.* net.]

All the World's Aircraft. (*War Flying Annual.*) Founded by the late FRED. T. JANE. Edited and compiled by C. G. GREY. London and Edinburgh: Sampson Low, Marston and Co., Limited. [Price 25*s.* net.]

Man and Machine Power in War and Reconstruction. By Captain J. W. PETAVEL, R.E. (Retired). With foreword by Sir ASUTOSH MOOKERJEE, C.S.I. Calcutta: Published by the University.

THE CHANNEL-TUNNEL PROJECT.—In view of the recent discussions in France and Italy, on the Channel Tunnel, Mr. C. Andreae critically examines in the *Schweizerische Bauzeitung* of September 7, 1918, the project of A. Sartiaux, making it clear, however, that his comments concern the project as described by A. Moutier in the Bulletin of the Société des Ingénieurs Civils de France of July-September, 1916. Reference is made in the criticisms to the experience gained in the Simplon Tunnel. The Channel Tunnel is to lie all through within the 60-m. layer of Cenoman chalk, and to be in the middle of the Channel about 50 m. below the sea bottom and about 100 m. below mean water level. Going from Dover, first in a loop westward, and then approximately eastward over to Sangatte, near Calais, and to Marquise, south of Calais, the whole tunnel length is to be 53 km., of which 39 km. will be submarine, the gradients on the English side (subject to modifications) reaching one in 55.5 and on the French side one in 100. Two parallel tunnels are to be driven, each circular, 5·6 m. in diameter, 15 m. apart (axial distance 20·6 m.), and to be joined every 100 m. by a cross gallery. There is further a drainage tunnel, 3 m. in diameter, starting on both sides from a lower level (at 130 m. below shore level) than the main tunnels and keeping on the north-east side of these tunnels, which it is to join in the middle and with which it is to be interconnected. The pumping shafts are first to be constructed, and the drainage tunnel is always to be pushed in advance of the main tunnels. All the spoil is to be removed through the drainage tunnel, which is to be provided with a 60-cm. gauge track for electric locomotives. This is one of the chief points criticised by Andreae, and if his assumptions as to the proposed rate of advance and other features be correct, such a narrow-gauge track would be quite incapable of dealing with the very heavy transport of materials in both directions, especially as the tunnel is to accommodate the high-pressure pipes for the drilling machinery and the ventilating pipes and to serve as drainage-conduit at the same time. Accumulator locomotives would be out of the question, moreover, and trolley wires in a crowded tunnel of 3 m. diameter appear very risky under the conditions. Another chief point criticised is the distance between the two main tunnels. Two single-track tunnels (instead of one double-track tunnel) are projected in order to keep the roof pressure down. But the proposed distance of 15 m. is too small; in the Simplon Tunnel the distance is 12 m. (axially 17 m.), and disturbances of the one tunnel by the other were observed during the building. In some respects the conditions are more favourable (more uniform) in the Channel bed than they are in the rocks of the Simplon; but in the Channel bed the results of any yielding and of a propagation of a disturbance upwards to the bottom of the sea would be fatal. Andreae would increase the distance between the two tunnels to 40 m. or 50 m. at least. That change would considerably increase the cost of the interconnecting galleries, of course; it is pointed out, however, that galleries are not needed at distances of 100 m.; in the Simplon the galleries were built 200 m. apart, and finally most of them were filled up again. Contrary to Sartiaux, who planned special ventilation, Moutier considered that the ventilation might be left to the trains themselves. Those and other details of the project do not appear to be settled yet; and many changes of design may yet be introduced.

THE LATE MR. JOHN PAUL WILSON.

WE regret to have to announce the death, which occurred at Harrogate, on the 4th inst., of Mr. John Paul Wilson, late General Manager of Palmer's Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne.

Mr. Wilson was a Clyde-trained engineer, having served his apprenticeship with Messrs. Denny and Rankin, Dumbarton. When quite a young man, he accepted an offer to go to Jarrow, where for two years he was employed principally on the plans of the troopship Jumna, which was built in 1866. He afterwards returned to the Clyde, and joined the staff of William Denny and Brothers, where he worked himself up to the position of Chief Draughtsman. After staying about three years with Messrs. Denny, Mr. Wilson was offered, and accepted, the position of Chief Draughtsman and assistant manager to the firm of Robert Napier and Sons. He then returned to Jarrow as Manager of Palmer's shipyard, and ultimately became the head of the shipbuilding and engineering departments of the latter firm. In the interim, however, he held the position of Manager of the Barrow Shipbuilding Company, in the early years of its existence; he was later, for several years, Manager of the Clydebank works of Messrs. James and George Thomson, now owned by Messrs. John Brown and Co., Limited; and also shipbuilding director of the Anglo-Spanish yard at Bilbao, which yard he designed and laid out to build 7,000-ton armoured cruisers in an unprecedented short time. When acting at Bilbao Mr. Wilson had the honour of being presented to the Queen Regent, on the occasion of the launch of the Infanta Maria Teresa, the first of three sister ships which were built and launched within twelve months of the date of signature of the contract, 90 per cent. of the labour employed being Spanish.

On leaving Spain, Mr. Wilson returned to Jarrow and took up the position of General Manager of Palmer's Shipbuilding Company. He was early to the front in the successful launch of the Russell, the first battleship to be launched in the United Kingdom in the new century and the first in the reign of King Edward. He retained the position of general manager to the company for many years until failing health compelled him to retire.

Mr. Wilson was a very genial man, and leaves a host of friends. He was 72 years of age at the time of his death.

IRON AND STEEL IN JAPAN.—In a recent report, says *The London and China Telegraph*, H.M. Consul at Shimonoseki draws attention to the growing importance of Japan's iron and steel projects. There is little doubt, indeed, that iron and steel manufacture is likely to supersede all other industries in importance, with the possible exception of that of coal production. The new works in North Kyushu are of special interest. The rail journey from Moji to Fukuoka traverses the district where the new steel works of North Kyushu are situated in close proximity to one another. Within a few years North Kyushu will merit the name of the "Black Country of Japan," which is already beginning to be applied to it. Along the narrow strip of land between the railway and the sea, centreing at Wakamatsu and Tobata, are to be seen iron and steel works. In addition, the existing works are in many instances greatly extending their capacity.

QUEENSLAND LIGHTHOUSES.—The special features of lighthouses on the Queensland coast formed the subject of an interesting lecture delivered recently to the Liverpool Engineering Society by Mr. Ramsbotham, Director of Lighthouses for the Commonwealth. He explained that the towers of the lights consist of four-legged steel structures, subdivided into four bars and braced in the usual way. The height of their platforms is 42 ft. 9 in. above the concrete foundations, the focal plane of the light being nearly 6 ft. higher. The foundations differ for each light. Those at Coquet Island and Clerke Island offered no special features, both being above high water and not subjected to any wave action. At Dhu Reef, where the actual site of the light is 18 in. below h.w.m.s.t., it was determined that at a depth of 9 ft. 6 in. the coral conglomerate, intermixed with sand, was sufficiently dense to stand a load of 2·375 tons per square foot. For the Piper Island light, which is established on a coral reef, it was ultimately decided to drive a nest of five ferro-concrete piles under each pier, excavating and putting a reinforced slab, 19 ft. square and 3 ft. thick, on the top. The necessity of driving the piles to a "sett" was recognised, but none of them could be so driven. In the author's opinion, nothing can be allowed for skin friction for piles driven in coral, and he decided to increase the bearing area to 963 sq. ft., reducing the intensity of stress to 0·725 tons per square foot. Acetylene dissolved in acetone at 10 atmospheres pressure is used, and there are 10 cylinders, each containing 117 ft., all coupled together. They are changed once a year. The light is turned on and off by a sun valve, which is so delicate that the light has been seen to come into operation during a rainstorm. A pilot flame is always burning. The lights are of 1,500 c.p., with a visibility of 13 miles. So far—i.e., since 1913—no trouble has been experienced with any of these unattended lights. The first cost compares favourably with that of a manned light, and the running cost is only 30*l.* as against 578*l.*

THE GERMAN COAL INDUSTRY.

A REPORT from the Ruhr districts states that during the last few weeks both production and sale of coal have fallen off, partly owing to labour conflicts and reduced capacity on the part of the hands. The reduction in the sale is also owing to the stocks having been disposed of during the summer months, so that the deliveries are now dependent upon the production. The transport by rail has for some time been fairly satisfactory, but will no doubt soon present the usual difficulties, and transport by water has also recently had to contend against many drawbacks. The water has been very low in the Upper Rhine and several sunken vessels have, in other places, impeded the traffic. The Upper Rhine, however, has been suffering from a shortage of coal, and coke and lignite have had to be used as substitutes. The coal-mining industry is producing coke on an ever increasing scale. The present annual production exceeds the peace production by some 5,000,000 tons, which naturally means a corresponding decrease in the available quantity of coal. Consumers cannot, however, always get the kind they want. Big coke, of course, cannot be used for domestic purposes and in works it is only wanted in foundries and blast furnaces. The mines do not at present appear to have the necessary appliances for producing large quantities of crushed coke, and during the war the installation of the requisite plant is out of the question.

Further, the price policy of the mines does not appear to have been very successful, either in times of peace or during the war. Prior to the war the sale was so sluggish that about 10,000,000 tons of coke were in stock when the war began, alone in the Ruhr district. In order to further the sale, the price had to be reduced 1·50 marks per ton in 1915. Owing to the reduced production during the first year of the war, and the shortage of coal which manifested itself, this stock of coke could be promptly disposed of, the more so as the price for coke was moderate compared with the prices ruling for coal. At the present time the relative price level is again a little awkward. At the last price regulation crushed coke rose 4 marks or, with the tax of 10 per cent., 4·40 marks, whilst the price for coal was only raised 2·55 marks per ton, including the coal tax. Under the influence of this price policy crushed coke II 40/60 has risen from the normal peace price of 18 marks per ton to 41.40 marks per ton, or 130 per cent., whilst, for instance, anthracite nuts III has only risen from 18 marks to 35·25 marks per ton, or no more than 95·8 per cent., whilst anthracite nuts II have risen from 21·75 marks per ton to 39·60 marks, or only 82 per cent. This policy in the matter of price regulation is hardly likely to further the sale of coke.

The demand for auxiliary products is very strong, and in spite of the increasing production it cannot be satisfied. The army, the navy and agriculture are all anxious to secure their portion, and of the three agriculture naturally comes off the worst. The principle of barter has also made its way into this branch; anyone who is able to deliver articles of food obtains ammonia. Of benzol there is hardly any available for private consumers, the army, the navy and the chemical industries appropriate it all, and even then their requirements are not satisfied. The prolongation of the new benzol union has encountered several difficulties, but is expected to be brought about in the end. Apart from the home market the neutral foreign countries, according to existing agreements, also have a claim upon certain quantities of coal in exchange for articles of food. The quantity guaranteed Holland and Switzerland amounts in the aggregate to about 200,000 tons per month. Two-thirds of the quantity for Holland is sent by rail and the remaining one-third by water. There are three trains daily carrying about 3,200 tons. Holland supplying both rolling-stock and men. The despatch to Switzerland takes place by water.

SIAMESE TRADE IN ELECTRICAL GOODS.—The comparative declared values of the imports of electrical goods into Siam from the leading foreign countries for the four fiscal years ended March 31, 1917, in ticals (1 tical equals about 37 gold cents, equals about 1s. 6d.), are shown in the following table taken from *The London and China Telegraph*:

Imported from	1913–14.	1914–15.	1915–16.	1916–17.
	ticals	ticals	ticals	ticals
United States ..	154,921	63,883	126,895	174,572
Austria-Hungary ..	4,684	10,957	53	—
Belgium ..	1,205	78	—	—
Denmark ..	26,607	3,912	24,673	10,739
France ..	24,698	5,063	4,946	4,784
Germany ..	574,867	167,407	4,926	—
Holland ..	805	7,166	21,000	51,062
Hongkong ..	29	—	—	5,166
Italy ..	12,943	8,711	28,463	29,711
Japan ..	972	69,979	26,555	263,394
Singapore ..	23,903	12,221	5,149	15,888
Sweden ..	1,943	8,267	21,917	30,683
Switzerland ..	15	—	—	4,710
United Kingdom ..	296,899	111,716	146,270	265,547

As shown by the foregoing figures, the trade of the United Kingdom in electrical goods with Siam made fair progress during the period under review, while the advance made by Japan in the same time was most striking. Holland, Denmark and Sweden also made considerable gains in these imports, to which Germany formerly was the heaviest contributor. As no electrical apparatus or goods of any kind are manufactured in Siam, there is naturally a demand for all classes of such goods, with the addition of specialties needed for a tropical country.

"COAL SAVING BY SCIENTIFIC CONTROL OF STEAM BOILER PLANT."

To the Editor of Engineering.

Sir,—I have read with much interest the letter of your correspondent, Mr. C. W. L. Nicol, in your issue of October 4, 1918. Mr. Nicol in his correspondence rather gives the impression that all that is necessary to obtain high boiler-plant efficiency and cheap steam production, is to substitute coke for coal, and that all plants burning coke are highly efficient. The matter is, however, much more complicated than appears at first sight, and before adopting coke in place of coal there is at any rate three very important points to consider, namely :—

1. The price of coke as compared with coal.
2. The quality of the coke.
3. The necessity of running the plant on efficient lines.

As regards the price of coke this is merely a question of local conditions, and I do not doubt that in many districts of London, other things being equal, that it is an economical policy to substitute coke and coke breeze for coal. Each case has to be decided on its merits, but certainly in some instances coal is better value. In comparing the relative values of Welsh coal, ordinary steam coal, and coke, Mr. Nicol takes 40*s.* per ton as an approximate price for ordinary steam coal. This seems somewhat excessive and some firms are at the present time only paying a little over 30*s.*

The quality of the coke, especially the percentage of moisture, is a very serious matter, and I can assure Mr. Nicol from practical experience that all coke and coke breeze sold in London is not free from excessive amounts of moisture, with a corresponding serious loss in efficiency.

The third and no less important point is that to obtain the highly efficient results possible with good quality coke at a suitable price, the boiler plant must be run on up-to-date lines, and adapted specially for the work.

There are many boiler plants running to-day that, with most favourable conditions as regards coke supply, are obtaining most inferior results because those responsible for the plant do not understand how to burn coke efficiently any more than they did coal.

Mr. Nicol says that "the average evaporation obtained per pound of coke as fired at various London factories, &c., is about 9·8 lb. from and at 212 deg. F., which corresponds presumably to about 80 per cent. efficiency or over." This statement as written applies to the whole of the boiler plants of London burning coke. I most certainly beg to differ, and I give below the figures of a boiler plant we have recently tested in London :—

Duration of test	9 hours.
Fuel used	Coke, approx. 36*s.* per ton delivered.
Analysis of coke used—	
B.T.U.	12036.
Ash	11·4 per cent.
Water	1·3 per cent.
Amount of coke used	2,175 lb.
Amount of coke burnt per sq. ft. grate area per hour	12·4 lb.
CO_2 on combustion recorder ...	10 per cent.
Water evaporated	14,672 lb.
Temperature of feed-water	157 deg. F.
Steam pressure	43·0 lb.
Water evaporated per lb. of coke ...	6·74 lb.
Water from and at 212 deg. evaporated per lb. of coke... ...	7·34 lb.
Net working efficiency of the plant	58·6 per cent.

Here the coke is of excellent quality, but the results of 7·34 lb. of water from and at 212 deg. F. are a very long way indeed below Mr. Nicol's average of 9·8 lb., and I am rather afraid there are a good many plants in London burning coke on no better figures than these. Perhaps Mr. Nicol's figure of 9·8 lb. applies only to plants under his own personal supervision.

I can only say again that provided the price and quality is right, coke is a most economical fuel and preferable to coal when efficient methods are adopted of running the plant, and I realise very fully the valuable work Mr. Nicol has done, and is doing, in this connection.

Yours faithfully,
(For Brownlie and Green, Limited),
D. Brownlie, Director.

Church Street, Cheetham, Manchester.
October 7, 1918.

To the Editor of Engineering.

Sir,—I read with very great interest the report by Messrs. Brownlie and Green, Limited, and was very much impressed by the great amount of useful matter it contained. The thanks of the steam users of the world should be tendered to them, for what, so far as my knowledge goes, is the largest compilation of useful information that has ever been published, on the subject. The letters addressed to you on it, in the majority of cases, do not add much. There is one striking exception, I refer to your correspondent, Mr. W. H. Casmey who, undoubtedly, is correct in his theory, that there is, or should be, a constant ratio between grate area and exit of furnace tubes in all tank boilers, if the theory of Professor Nicolson be right, that the higher the velocity of heated gases passing along a furnace tube, the greater the transmission of heat. Not one of your correspondents mentions the rate of heat transmission, which is approximately the square of the differences of the temperature on each side of a furnace tube, one is a constant, the other may be increased very considerably, by adopting Mr. Casmey's reduction of grate area ; I admit that his reduction appears too much, and too drastic, but practice has convinced me that he is absolutely correct. The fault lies in the ridiculous design of the Lancashire boiler, which with few exceptions has not been changed for seventy years ; anything which is an innovation is received with scorn by the powers that be. Had the man who seated the first Lancashire boiler set it the other way about, results would have been much better. At the rear end of the furnace tube you have a given suction; if you restrict it at the other end you will increase the velocity through the restricted portion (the grate) ; if thick, clean fires are kept you are enabled to burn your fuel faster, with an increase of temperature, hence a greater transmission of heat—herein lies the efficiency. In many cases where I have been called in for advice, shortening the grates, having the seatings made airtight, has without exception remedied the shortness of steam and stopped the black smoke. What I have said only proves that the design of the Lancashire boiler is wrong, and that Mr. Casmey's grate and exit theory, is an attempt to overcome error of design. A few essential facts may be useful to your readers.

1. The greatest head of water should be located over that part of the furnace tube where the gas temperature is highest.
2. In the presence of radiant heat gas films cannot exist.
3. The higher the temperature the greater the transmission of heat per unit of time.
4. Nicolson, Dalby and others have demonstrated that heat transmission is proportional to the speed at which the heated gases travel. These are facts (which Professor Nicolson proved by his freak boiler—I believe, constructed by Daniel Adamson), showing that boiler design is wrong, and Mr. Casmey has attempted to correct it by supplying a proportional grate. Although I have been shortening grates for the last fifteen years, I never hit upon the correct ratio. The four Lancashire boilers referred to in Mr. Casmey's last letter, I know quite well ; they are at a public institution, under the charge of a competent engineer, and are, as stated, giving an overall efficiency of 85 per cent. Why cannot all the boilers in the country do the same ? The plant consists of four 30 ft. by 8 ft. Lancashire boilers fitted with coking stokers, with induced draught, economisers, and each boiler has a separate draught gauge. A combustion indicator, giving a constant reading is installed, which the stokers work their fires to, and they use it as they do their pressure gauge. This is the whole of the plant that is giving such excellent results—and they are excellent. If you turn to Messrs. Brownlie and Green's report, out of the 250 plants only two gave over 80 per cent., or 0·8 per cent. of those examined. Why does not the Coal Controller insist upon coal being burnt economically ? The Government of the United States of America are insisting (see *The Times Engineering Supplement*, August, 1918).

To sum up, what they are doing means that all boilers will have to be fitted with instruments to detect excess air, pyrometers, CO_2 indicators ; in fact, to comply with conditions 3 and 4 it will be absolutely necessary to install CO_2 indicators : under no other conditions could they be complied with. All your correspondents are straining at gnats, and swallowing camels, the crux of the whole question is a proportionate grate, airtight seatings, plenty of draught, natural, or preferably induced, draught gauges, and above all a CO_2 indicator, without which no man can get such results as those I have given above.

Yours faithfully,
"Get a Move On."

"LIQUID CRYSTALS."

To the Editor of Engineering.

Sir,—Metallurgists, and engineers who use the microscope, will have read with interest the article on "Liquid Crystals," appearing in your issue of September 27, page 349. Although the subject lies outside ordinary practice, it may be of indirect importance. We may well believe that the behaviours of such crystals, influenced by the forces of surface tension and crystallisation, are in some measure related to the behaviours of metallic crystals at high temperatures, too high to admit of direct microscopical examination. It may be of service to suggest the possibility of such relationship.

Almost the whole of the article cited is devoted to a review of the crystalline properties of these remarkable substances. The evidence of crystalline nature is convincing and will not here be queried. On the other hand, very little, if any, evidence is brought forward to justify the assumption that the crystals are "liquid" in any scientific sense of the term. That such crystals ". . . may drift in a trough across which wires have been stretched and float right through the wires to close up again and reassume their original shape and properties" is no proof of fluid nature, since the same effect may be demonstrated for "solid" ice as well as for "liquid crystals." Tyndall's experiment, in which a loaded wire is passed through a block of ice without cutting it in two, is well known, and appears to be strictly comparable.

The phenomena of the "regelation" of ice were established in 1849 by Professor James Thomson ; and were applied by him to explain the plastic flow of ice in glaciers. It appears that the same explanation may suffice to account for the apparently liquid nature of these organic crystals. Published descriptions of their physical properties appear to indicate that such plastic crystals are solid bodies endowed with very low modulus of elasticity and with the faculty of performing regelation phenomena under comparatively low pressures.

Such crystals might more properly be termed "plastic," instead of "liquid" or "fluid." But the point is not merely one of nomenclature, for the premature use of the term "liquid" may tend to obscure the real nature of phenomena which, if sufficiently investigated, might elucidate important problems connected with the crystallisation and structure, and strength of alloys.

Yours faithfully,
B. P. Haigh.

Royal Naval College, Greenwich.

"PAYMENT BY RESULTS."

To the Editor of Engineering.

Sir,—The following is in reply to the letters on "Payment by Results" appearing in your issue of September 27. Mr. McPherson's letter is devoted to the need for every concern being run on the most efficient and just lines possible—an accepted elementary basis which applies irrespective of whether or not a system of payment by results is in operation.

Mr. Grosant's statements are not complete, and they misrepresent the case. His contention that "the adaptability of the two systems" (*i.e.*, piecework and premium bonus) is identical is quite wrong. The difference concerned is very marked and if he re-reads my article and substitutes "piecework" for the words "the employer does not share in the saving in labour cost" he will find a few examples of differences which render the premium bonus system capable of adjusting itself harmoniously to natural difficulties while piecework has the opposite effect.

His figures cannot be taken seriously. He saddles a system for rewarding extra effort with the affairs of normal effort. He works on a basis of labour receiving eight to ten times the amount received by capital on time conditions, and (taking account of oncost which, if his comparison is legitimate, is also taken account of in the 8, 10 and 1 reference) by effecting a saving of 25 per cent. under the "Rowan" system, transforms this into a proportion of 26·25 and 18·75 in favour of capital.

There is no need to make assumption or deal with hypothetical figures in the matter. Premium bonus is a system for inducing and rewarding extra effort. The only just basis on which to judge it is to start from fair time conditions. If by putting forth extra effort a man increases his output his reward for normal effort is increased in proportion to that extra effort. How much of the saving effected is due to the man himself, how much to facilities provided by, and management of, his employer, and how much should be utilised for reducing the selling price of the article so as to leave both parties in the same proportionate positions as on normal conditions, will always be a matter of opinion. In considering the matter one must not lose sight of the fact that human beings, castings and forgings are variables, and that a workable system must be capable of providing for these variables harmoniously.

In classes of work where an improvement on overhead production at short intervals can be suitably ascertained, the increasing of wages on that principle has much to recommend it. Unfortunately, engineering and shipbuilding generally do not lend themselves to such a system, and therefore it becomes necessary to have a system for sectional or individual effort. Those who have a working knowledge know that a man can save 25 per cent. of the time allowed without in any way overexerting himself, and a system which rewards that saving by increasing the worker's wages by 25 per cent.—as does the Rowan system—cannot be discredited by describing it as a "nostrum" or ignoring its practical application.

Yours truly,
D. I. M. Larty.

Glasgow, October 7.

The Midland Institute of Mining, Civil and Mechanical Engineers.—A general meeting of the members of this Institute will be held at the University, College-road, Leeds, on Thursday, the 17th inst., at 3 p.m. The meeting will be of a social character, and, on the invitation of the Pro-Chancellor of the University of Leeds, Mr. Arthur G. Lupton, LL.D., certain departments of the University will be open for inspection by the members throughout the day of the meeting. There will be exhibited models, instruments, displays from the Department of Fuel, Gas and Metallurgy, and numerous other collections. The meeting will close at 6.30 p.m.

Electrification of Swiss Federal Railways.—The Commission of the Administration of the Swiss Federal Railways has decided to proceed with the introduction of electric propulsion—which practically means further utilisation of hydro-electric power—in three groups of lines, each of which is expected to be completed in about ten years. The probable costs were estimated at 500,000,000 francs before the war ; the war conditions will raise that figure by at least 50 per cent., it is thought, so that, apart from rolling-stock, a sum of 25,000,000 francs will have to be set aside annually for the space of thirty years. On the other hand there will be a great saving in coal, a very important point for Switzerland. Group I comprises the railways of the southern high Alps and their connections, Erstfeld-Bellinzona–Chiasso–Luzern–Zürich ; Iselle–Brig–Sion–Geneva–Lausanne–Bern–Thun–Basle ; Olten–Zürich–Schaffhausen. Among the new water-power schemes for this group are the plants at Ritom-Amsteg (10,000 h.p. and 15,000 h.p.), Barberine (7,000 h.p. and 9,000 h.p.), Rupperswil on the Aar (8,000 h.p. and 160,000 h.p.), Etzelwerk (9,000 h.p.). The lines of Group I total up to 1,182 km., making up two-fifths of the whole network of the Swiss Federal railways. Group II, of 601 km., comprises the lines Zürich–Chur, Bern–Luzern–Interlaken–Solothurn, La Chaux-de-Fonds, Lausanne–La Chaux-de-Fonds and other lines of the Jura ; some 25,000 h.p. will be required. The railways in Northern Switzerland along the Rhine belong to the third group.

A METHOD FOR THE PREVENTION OF GROWTH IN GREY CAST IRON.*

By J. E. Hurst, Acton.

The phenomenon of growth or expansion of grey cast-iron when subjected to repeated heatings in an oxidising atmosphere has been shown to be due to the increase in volume consequent upon the internal oxidation of the various constituents by means of the gradual penetration of the oxidising gases into the centre of the grey cast-iron mass; while it has been shown that the whole of the constituent silicon is comparatively rapidly completely oxidised, and the total growth experienced is roughly proportional to the extent of silicon present in the original iron.

The primary cause of growth is the presence of the free graphite plates which allow of the entry and penetration of the oxidising gases into the interior of the iron. It has been experimentally shown that in those white cast irons in which free graphite is absent, the total expansion is almost negligible, and for the most part can be accounted for by the precipitation of free carbon in the nodular annealing carbon form.

It is of considerable importance to note that malleable cast irons in which the free carbon exists in the nodular form of annealing carbon do not grow. This is the result of the fact that the graphite in these irons does not present a continuous path for the penetration of the oxidising gases into the interior of the mass.

On these grounds, therefore, it will be readily appreciated that any method whereby the entrance of the oxidising gases into the interior of the casting is prevented will simultaneously prevent growth. Methods in which the outside surface of the material is coated with a layer of impervious refractory enamel readily suggest themselves as a means whereby the entry of the oxidising gases may be prevented. Apart from the difficulty of obtaining a suitable enamel, such methods would entail many disadvantages in the majority of circumstances.

The removal of the free graphite from the exterior surface layers of the cast-iron would appear to be an ideal method for preventing the penetration of the oxidising gases. Such a method would amount to the production of a skin or "case" of decarbonised material round the cast-iron which would effectually prevent the entry of the oxidising gases. By this means growth would be prevented, and the use of alternative white irons which involve difficulties in machining would be obviated.

The suggestion that the growth may be prevented in this manner has previously been made by the author.†

An example has been recorded in the shape of a length of grey cast-iron water pipe, 4 in. in diameter and about $\frac{1}{16}$ in. in thickness, which was prevented from growing by the formation of a protecting "case." The pipes were repeatedly maintained at a temperature in the region of 800 deg. C. and 900 deg. C. alternatively for a considerable period in a strongly oxidising furnace atmosphere. The chemical composition of the cast-iron was as follows:—

	Per Cent.
Combined carbon	nil
Total carbon ... (by combustion)	2·20
Graphite	2·20
Silicon	2·66
Manganese	0·46
Sulphur	0·096
Phosphorus	0·95

This analysis was taken from the material after exposure to the heat, the low total carbon content being due to the unavoidable inclusion of drillings from the decarbonised portion of the iron. It was found on examination of the silica precipitate from the silicon estimation that the whole of this precipitate was quite white and flocculent. This is confirmatory evidence of the absence of internal oxidation.

On fracturing the iron, the inner core of grey graphitic iron, surrounded on both sides by a "case" having a bright steely fracture, was rendered plainly visible. Photomicrographs taken from a section cut from this pipe are illustrated in Figs. 1 and 2, annexed. In Fig. 1, a photograph of the unetched sample, the completeness of the decarburisation and the almost entire removal of the graphite plates are clearly shown. In the photograph of the etched sample, Fig. 2, small traces of nodular areas, consisting possibly of carbon in the annealing carbon form, are revealed in the case. It is extremely interesting and important to note the existence of the phosphide eutectic constituent in the decarbonised case. This constituent was evenly distributed throughout the original material. In the interior of the heat-treated specimen the graphite appeared to exist in a finely-divided, possibly annealing, carbon form. The presence of holes was also noted, as would be expected as a consequence of the removal of a portion of the phosphide constituent. Many of the larger black areas in the interior, as shown in the photograph, were apparently filled with finely-divided carbon. There is no doubt that the heat-treated sample was somewhat more brittle than the normal metal; but in spite of this, it is very important to note that the heat-treated iron possessed none of the "rottenness" associated with "grown" irons.

Previous to exposure to heat these pipes were heavily coated with a thick scale of rust (hydrated ferric oxide). It is considered that the initial presence of this scale has largely contributed to the decarbonisation. In his repeat experiments the author has met with success by prolonged annealing in this material.

The possibility of the complete removal of the graphite plates and the entire absence of spaces where the graphite originally existed, when heat treated under oxidising conditions, is clearly proved by the photomicrographs. So far as the author's knowledge goes, this observation is entirely new.

The possible methods by which graphite might be removed without the subsequent production of cavities in the metal are briefly summarised below:—

1. Superficial decarburisation and the oxidation of the graphite followed by the liquation of the phosphide eutectic into the remaining cavities.

2. At temperatures of over 900 deg. C. within the range of temperature to which the above-mentioned samples have been exposed (900 deg. to 1,000 deg. C.) it is certain that a considerable portion of the graphite is redissolved, forming the austenite solid solution.

In those irons containing considerable quantities of phosphorus the conditions are considerably more complex, but there is every probability of the re-solution of the graphite taking place with the production of complex ternary constituents. Under these circumstances the possibility of the removal of the graphite with the entire absence of holes will be appreciated.

Further investigation is necessary before a complete explanation of the mechanism of the surface decarburisation can be satisfactorily given. It appears extremely probable in this particular case that decarburisation of the superficial layers of the austenite in direct contact with the heavy scale of ferric oxide primarily takes place. The austenite solid solution, in addition to the carbon originally existing as combined carbon, possibly contains some of the graphite dissolved, and in this manner the graphite is removed from a superficial layer and the entry of the oxidising gases prevented.

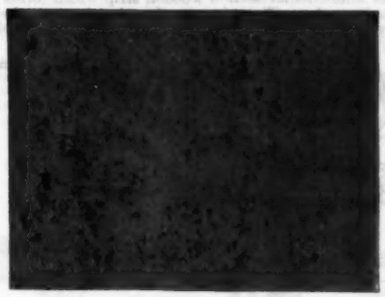

Fig. 1. Decarbonised Surface on Grey Cast-Iron. Unetched Sample. × 75 Diams.

Fig. 2. Decarbonised Surface on Grey Cast-Iron. Etched 1 per Cent. HNO_3. × 100 Diams.

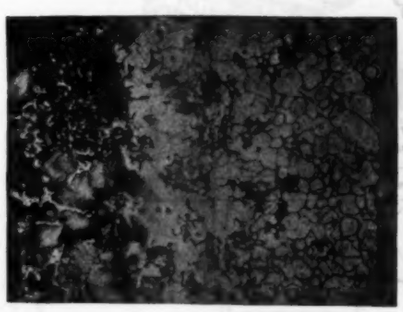

Fig. 3. Decarbonised Surface on Grey Cast-Iron. Etched for 45 Seconds with Stead's Cupric Chloride Reagent. × 100 Diams. Reduced by One-Third. In each Figure the Core is to the Left and the Case to the Right of the Illustration.

The original analyses of the above-mentioned specimens are not known, but it is legitimate to assume that the original carbon contents of this class of casting would be as follows:—

	Per Cent.
Total carbon	3·25
Graphite	2·75
Combined carbon	0·50

It will be seen therefore that about 1 per cent. of the total carbon is removed by oxidation, and this is very probably all removed at the high temperature, whilst in the austenite condition, by the gradual diffusion of the austenite towards the decarbonised portions. This assumption is borne out by heat-treatment experiments on a similar class of iron, in which it has been shown that when quenched from a temperature of 900 deg. C. to 950 deg. C., over 1 per cent. of carbon can be retained in the dissolved austenite form.* The presence of carbon in the annealing carbon form noticed in the core of the specimen is also additional proof of the fact that the graphite has been redissolved and reprecipitated in this form on slow cooling.

It is of considerable importance to note the diffusion of the phosphorus in this particular sample. Fig. 3, annexed, is a photograph of a similar specimen to the above-mentioned etched with Stead's cupric chloride reagent. As will be seen from the photograph, the whole of the decarbonised case is entirely unaffected by the reagent, showing that, in addition to the binary eutectic, a considerable amount of the phosphorus of the sample exists in solid solution in the decarbonised case.

It is considered in this particular instance that the diffusion of the phosphide is for the most part a secondary phenomenon. The phosphide will commence to dissolve as the concentration of the austenite solid solution is gradually reduced, and, as has been shown by Dr. Stead, the dissolved phosphide will tend to diffuse to the decarbonised portions (*i.e.*, the outside edges) and will tend to become concentrated in those portions.

In the absence of further data, which, owing to lack of time and materials, has not been obtained, very little further can be added to this explanation, which is admittedly only tentative.

It will be readily appreciated that the production of a decarbonised case around cast-iron articles in this manner will be of considerable service in the prevention of growth under many circumstances. It has already been suggested that this method should find application in the protection from growth of dies and permanent moulds for iron and non-ferrous metals. Other important uses suggest themselves, such as the protection of valve seatings and valve guides in internal-combustion engines. For this purpose further experimental work will be necessary accurately to determine the conditions under which this graphite can best be removed. The author has several permanent moulds which have been protected in this manner by annealing at a temperature of 900 deg. to 950 deg. C. in ordinary brown rust (oxide of iron) for a period of 72 hours. The results have also been considerably improved by raising the annealing temperature to 975 deg. to 1,000 deg. C. Troubles however, have been experienced in these cases through distortion. At this high temperature (from the preliminary investigations already made) the removal of the graphite would appear to be brought about through the formation of the ternary eutectic of iron, phosphorus and carbon, and in this respect is somewhat different to the above-mentioned case.

In conclusion the author wishes to express his regrets that, owing to the lack of time and materials, he has been unable to investigate this phenomenon as thoroughly as it deserves. There is every possibility that this phenomenon, when fully investigated, will be of considerable service in the direction mentioned.

Serbian Copper Mines.—The Serbian copper mines yielded 5,335 tons in 1910 and 7,600 tons in 1913. Under the management of German and Austrian engineers, the mines have been worked in the interests of the Central Powers. The ore contains from 6 per cent. to 9 per cent. of copper.

Terrestrial Magnetism and Solar Activity.—It is well known that violent fluctuations in the earth's magnetism occur during periods of intense solar activity. These fluctuations may subside after a few hours or days. There may also be an after-effect of a quiescent persistent character, however, and the magnetism may remain below par for several months after a magnetic storm, and it is not certain that the earth really returns to its former state. Under the circumstances it is very difficult to settle the normal value or base line of the magnetic elements. In most of these analyses periods of a few years are considered. Lecturing before the Washington Philosophical Society this summer A. L. Bauer gave the results of an investigation covering a period of 2½ solar cycles, 1888 to 1916, and taking the values of the solar constant of radiation into consideration. It would appear that, in selecting a common epoch to which the magnetic elements resulting from a magnetic survey shall be reduced, regard should be paid to the position of the epoch with reference to the years of maximum and minimum solar activity. The factors which affect terrestrial magnetism certainly lie both within and without the earth, and the secular variations are due to changes both in the direction and in the intensity of the magnetisation of the earth.

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* Paper read before the Iron and Steel Institute.

† See *Proceedings of the Staffordshire Iron and Steel Institute*, December, 1917, and *Journal of the Institute of Metals*, 1918, No. 1, page 142.

* Journal of the Iron and Steel Institute, 1916, No. II.

A.E.G. ARMOURED AEROPLANE.

We reproduce below from a report recently issued by the Ministry of Munitions the following particulars of an A.E.G. armoured aeroplane which was brought down by an R.E.8 of our 21st Squadron, near Hinges, on May 16, 1918.

This aeroplane is designed for the purpose of carrying out offensive patrols against infantry, and is furnished with armour, which affords protection for its *personnel*. This armour appears, however, to be more or less experimental. In general construction it closely follows the lines of the A.E.G. twin-engined bomber G.105, though the arrangement of the power plant is, of course, entirely different. A steel tubular construction is used practically throughout. The machine was badly crashed, and some details are, therefore, not available; but the general arrangement, as shown in Figs. 1, 2 and 3, may be regarded as substantially accurate. The leading particulars of the machine are as follow:—

	Sq. Ft.
Area of upper wings	190·4
Area of lower wings	168·0
Total area of wings	358·4
Area of upper aileron	11·2
Area of lower aileron	10·0
Area of tail plane	9·4
Area of fin	7·6
Area of rudder	6·0
Horizontal area of body	48·6
Side area of body	54·8
Cross sectional area of body	14·4
Area of side armour	33·0
Area of bottom armour	29·4
Area of armour bulkhead	10·4
Engine, 200-h.p. "Benz."	
Crew—pilot and gunner	360 lb.
Armament—three guns.	
Petrol capacity	38 Gallons.
Oil capacity	3

Fig. 1.

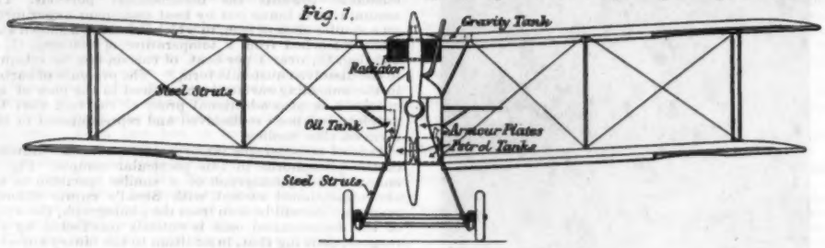


Fig. 2.

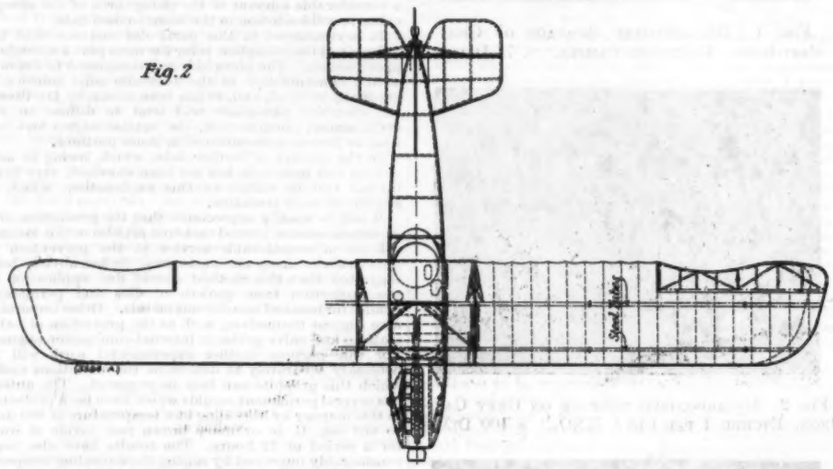
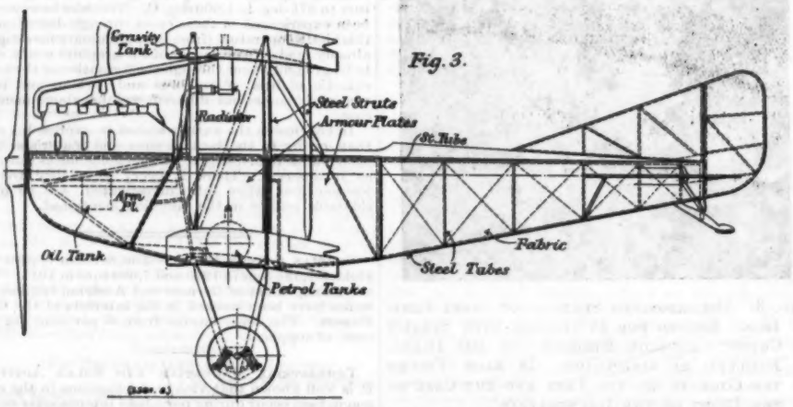


Fig. 3.



Wings.—The manner in which the wings are constructed is exactly as shown in the report of the A.E.G. Bomber, i.e., the spars consist of two steel tubes, 40 mm. in diameter by 0·75 mm. thick. At their ends the upper and lower surfaces of the spars are chamfered away, and flat plates welded in position, so as to provide a taper within the washed-out portion of the wing tips. The wings were, unfortunately, so badly damaged that no accurate drawing of their section can be taken, but there is evidence that this very closely follows the section of the bomber. The ribs are of wood, and between each main rib is placed a half-rib joining the front spar to the semi-circular section wooden strip which forms the leading edge. The wing construction is strengthened by two light steel tubes passing through the ribs close behind and parallel to the leading spar, which are used for housing the aileron control wires. The bracing against drag consists of wires and transverse steel tubes welded in position. At the inner end of the wings special reinforced ribs of light-gauge steel tube are provided. The method of construction at this point is clearly shown in Fig. 4, which also indicates the manner in which the bracing tube is welded to a socket driven on the main spar. The spars are attached to the fuselage by plain pin joints.

Centre Section.—The centre section of the upper surface is constructed in a similar manner to that of the wings, except that it is considerably reinforced, and the spars are larger in diameter. The leading spar has a diameter of 51 mm. and the rear spar 45 mm. The centre section is secured to the fuselage by a system of stream-lined steel struts, the feet of which terminate in ball-ends dropped into sockets, and there bolted in position. One of these struts is shown in Fig. 5. The centre section contains an auxiliary gravity petrol tank, and also the radiator, and is, therefore, substantially braced with steel tube transverse members. The wings are set with a dihedral angle of approximately 6 deg.

Ailerons.—The aileron framework is of light steel tube throughout, the tube forming the trailing edge being flattened into an elliptical section. The ribs are fixed by welding. The framework of the ailerons on the upper wing is reinforced by diagonal bracing of light tube.

Struts.—These are of light steel tube stream-line in section, tapered at each end, and terminating in a socket which abuts against a ball-headed pedestal carried on the wing spars; through the socket and the ball is passed a small bolt.

Fuselage.—The whole of the fuselage is built up of steel tubes welded together, and having affixed at their junctions sheet steel lugs, which serve as the anchorage for the bracing wires. The diameter of the longerons and of the frame verticals is 20 mm., except the last three members adjacent to the tail, of which the diameter is 16 mm. The welding throughout the fuselage appears to be of very high quality. In Fig. 5 is illustrated a joint, which occurs in the fuselage immediately in front of the pilot's cockpit. The longeron is, from this point to the rear of the gunner's cockpit, fitted with a wooden strip taped in position. This joint shows the method in which the cross-bracing wires are furnished with an anchorage. In one or two points in the frame construction the bracing wire lies in the same plane as the transverse tube, and to allow for this a diagonal hole is drilled through the tube, and filled in with a small steel tube welded in place.

Fig. 4.

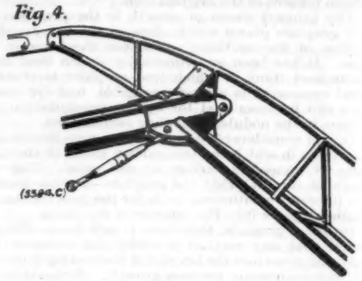
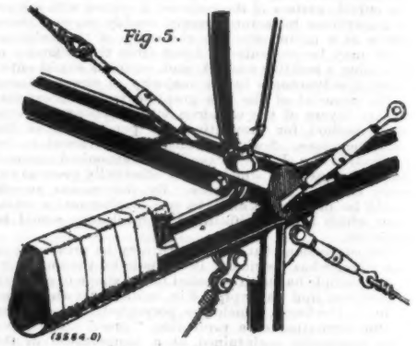


Fig. 5.



Engine Mounting.—This consists of a triangulated arrangement of steel tubes carrying hollow rectangular section steel bearers, on which the crank chamber is slung. The bearers are well trussed both in the vertical and horizontal planes, and are shown in dotted lines in the general arrangement drawings. The engine bearers themselves are 2 mm. in thickness, and have an approximate section of $2\frac{1}{16}$ in. by $1\frac{1}{4}$ in.

Tail.—The empennage possesses no particular points of interest, the planes having the usual steel tubular framework. The tail plane is not fitted with any trimming gear, but a method of adjustment is provided. This is shown in Fig. 6, which is self-explanatory. The diagonal struts which proceed from the base of the fuselage to the tail plane spar are fitted at each end with a method of adjustment shown in Fig. 7, allowing them to be extended as required according to the particular socket which is used to carry the leading edge of the tail plane. Neither the elevators nor the rudder are balanced. The rudder post is mounted on the end of the fuselage, as shown in Fig. 8, in which it will be seen that the vertical frame tube of the fin is very stoutly attached to the frame by a triangulated foot.

Landing Gear.—This is of the usual A.E.G. type, and is furnished with shock absorbers consisting of metal coil springs in direct tension, as is clearly shown in the general arrangement drawing. The landing carriage axle has a diameter of 55 mm. The landing carriage struts, which are of similar section to those used between the planes, measure 70 mm. by 37 mm. At their upper ends they are furnished with ball and socket attachments similar to those of the interplane struts. The wheels are fitted with 810 mm. by 125-mm. tyres, and the track is 6 ft. $10\frac{1}{2}$ in. The tail skid is unusually heavy, and it is a built-up construction of welded sheet steel. It is mounted on a stout tail post, which is reinforced by four stream-line steel diagonals. The forward end of the tail skid projects inside the fuselage, and is there provided with four steel springs in direct tension. A sketch of the tail skid is given in Fig. 9.

Control.—This consists of the usual double-handled lever mounted on a transverse rocking shaft, which carries the elevator control cranks at each end. The upper ailerons are worked positively by wires which pass over pulleys on the wings spars at the outer struts, the

outer and lower ailerons being connected by a stream-line steel tubular strut.

Engine.—The 200-h.p. Benz engine possesses no new features.

Petrol System.—Underneath the pilot's seat are the two main petrol tanks, each of which contains 80 litres (equals 16 gallons). These tanks are of brass, and are fitted with Maximall level indicators. The gravity tank, containing 27 litres (equals 5¼ gallons) is embedded in the centre section of the upper plane, where it forms the leading edge on the left-hand side. This tank is made of lead-covered steel. Cocks are provided, so that either the gravity tank or the pressure tanks, separately or together, can feed the carburettor. It is of interest to note that the chamber which is used in connection with the Benz petrol supply system is not, as is usually the case, contained in the main tank, but is a separate fitting mounted on the side of the engine.

Radiator.—The radiator is of the Daimler-Mercedes type, measuring 32½ in. long by 11½ in. high and 6 in. deep. This is fitted with imitation honeycomb tubes, of which there are 118 running vertically, each being fitted with 48 gills. The radiator is carried in a steel cradle, into which it is easily inserted from above, and this in turn is supported on specially built-up steel ribs. It is placed so that the tank which forms the upper part of the radiator lies about flush with the centre section of the top plane. The shutter or flap for controlling the water temperature is made of three-ply wood stiffened with a light steel framework, and is mounted immediately behind the radiator, being worked by a handle within reach of the pilot. This handle is provided with a rack and pawl device. The shutter is 3¾ in. deep, and is capable, therefore, of covering up about one-third of the total radiator surface. It will be noted that the position of the shutter behind the radiator is unusual.

Armour.—Protection for the pilot and gunner is afforded by armour, which is shown in the general arrangement drawing in thick lines. There are three panels at each side, and three panels at the bottom of the fuselage, an armour bulkhead being placed at the rear of the gunner's cockpit to protect him from behind. The armour is 5·1 mm. thick, and its total area is 105·8 sq. ft. The weight of the armour is thus approximately 860 lb. Careful tests have been made to ascertain the effectiveness of this armour, and the annexed table gives the ranges at which these plates are safe or unsafe against penetration by bullets of various types. The figures may be taken as correct within the limit of a practical firing test.

The armour is undoubtedly too light to afford protection against British armour-piercing bullets fired from the ground at a lower height than 500 ft., while a machine armoured with it would have to fly at, at least, 1,000 ft. to be safe from all but a very low percentage of hits. The armour does not appear to have been employed, as it might well have been, in a structural capacity, i.e., it is simply an attachment to the framework, to which it adds no material strength. Its appearance seems to point to the fact that it had been added by way of experiment, and that it was of a more or less makeshift character. It had, for instance, evidently been necessary to open out existing holes and cut new holes in the course of erection. The armour is attached by set screws to clips clamped on the fuselage members, as shown in Fig. 10.

Armament.—In this machine the pilot is not provided with a gun, but the observer has to control three, of which two (Spandau) are fixed on the flooring of his cockpit), whilst the other (Parabellum) is carried on a rotatable mounting. With regard to the fixed guns, these are secured to a couple of tubular steel brackets, mounted as shown in Fig. 11. The oval-section steel tubes, of which these brackets are composed, are welded to a light steel base, which forms a sort of tray, and is in turn bolted to the panel of armour which forms the floor of the cockpit. Adjacent to these two guns, which fire forward at an angle of 45 deg., is a bracket carrying the belts of ammunition, which are fed from a large rotating drum.

In the right-hand front corner of the pilot's cockpit floor is a circular hole, which he would appear to use for sight purposes. The fixed guns are controlled by Bowden wires and triggers mounted on a diagonal frame member, convenient to the gunner's right handle as shown in Fig. 12.

The movable gun is of the Parabellum type, and the mounting is of the usual built-up wood variety. The gun cradle is, however, novel, the fixture for this purpose being illustrated in Fig. 13. It appears to be rather more handy than the usual German device, but is by no means lacking in weight. This fitting was in a very badly smashed condition. The vertical carrier is swivelled at its base, and is secured in position by sliding bolts engaging with teeth cut in the turned-up base plate. These sliding bolts are worked by a direct-acting thumb lever. The turntable is made of a single hoop of wood reinforced at the point where the gun is mounted by glued-on strips of ply-wood. A locking device of the type shown in Fig. 14 is fitted.

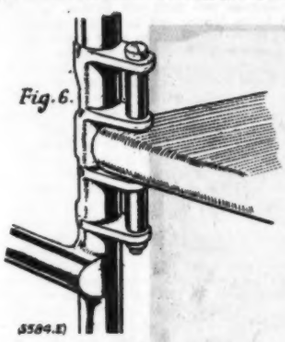
The transverse bracing in the immediate rear of the gunner's cockpit, at which point is mounted the armour bulkhead, suggests that it was the original intention for this aeroplane to carry a gun or guns firing downwards and backwards through a hole in the fuselage. The transverse arrangement of steel tubes and bracing wires is shown in Fig. 15.

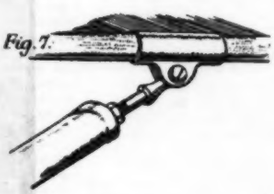
Wireless and Heating.—The machine is fitted with the usual wireless leads and apparatus for heating, the dynamo being carried on a bracket attached to the fuselage immediately in front of the pilot's seat, where it is directly driven from the engine through a hand-controlled clutch. No wireless fittings, other than the dynamo and the leads, were found on the machine.

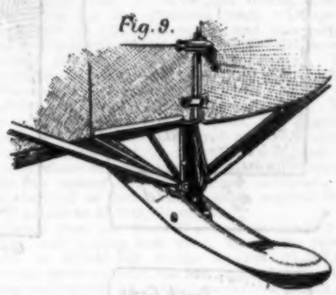
The instruments fitted to this machine are of standard type, and possess no new features of interest. The fabric throughout is of good quality, but the dope appears to have been badly applied, as in many points it had completely peeled off the fabric. The colours used are dark purple and dark green, and in contradistinction to the usual method by which they are arranged in well-defined polygons, are applied so as to give a cloudy effect, and appear to have been sprayed on.

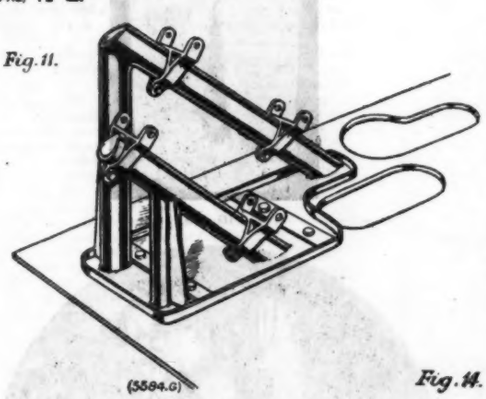
Steel Analysis.—A sample of the wing spar yields the following analysis :—

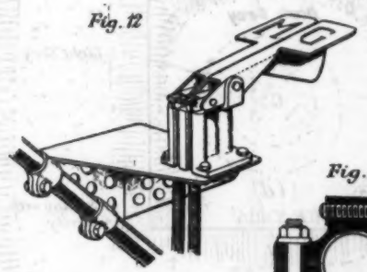
	Per Cent.
Carbon	0·098
Silicon	0·011
Sulphur	0·017
Phosphor	0·014
Manganese	0·461
Chromium	0·036

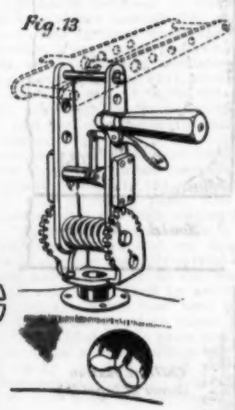












Ammunition.	Angle to Normal Degrees.	Safe Range. Yards.	Unsafe Range. Yards.
German A.P. ...	0	—	600
	15	500	400
	30	400	300
Mark VII P. Armour piercing	0*	700	600
	15	400	300
	30	300	200
German Spitze ...	0	150	100
	15	100	50
	30	50	—
Mark VII	0	50	—
	15	50	—
	30	50	—

* Probably.

GAS CONSUMPTION IN GERMAN TOWNS.—From a paper read by Dr. E. Schilling before the June meeting of German gas industrials we see that the consumption of coal-gas has much increased in German towns within recent years. The statistics given end with the year 1916–17, and were little affected by the restrictions in the gas consumption which was enforced later in 1917; a reduction of street lighting was already in force, however. Calculated per head of population the gas consumption was very much larger in large than in small towns. Thus in towns with more than half a million inhabitants the gas consumption had risen from 89 cub. m. in 1902–3 to 112 cub. m. in 1911–12 and to 128 cub. m. in 1916–17, whilst the figures for towns between 50,000 and 100,000 inhabitants were 62 cub. m., 72 cub. m., and 93 cub. m. respectively, and in towns with up to 10,000 inhabitants the figures were 46 cub. m., 70 cub. m., 76 cub. m. The consumption had increased at a more rapid rate than the growth of population. The statistics compiled by Dr. Schilling referred to works, consumers, mains, meters, &c.; additional statistics on the consumption of coal and electricity would, of course, be required to show whether this development is to be considered an advance from the general economical standpoint. A very significant statement was made during the meeting. It was insisted that not only gas-coal would have to be used very sparingly, but that the store of lamp oil available for the coming winter was very much smaller than last winter.

ON THE COOLING OF STEEL IN INGOT AND OTHER FORMS.*

By J. E. Fletcher, Dudley.

(*Concluded from page* 374.)

Influence of Cooling on Crystalline Structure.

The author has made many observations on the rate of freezing of cast-iron and steel, and has found, as might be expected from what has already been said, that the temperature gradient curve is an index to the speed of freezing from the surface to the axis of the ingot or casting. Thus in the 5·5-in. ingot cast in a mould sufficient clearness the difference in the structure. The chill developes and the concentric rings of varying graphitic character, with the central cores of coarsely graphitic metal almost exactly circular in outline, are distinctly comparable, and when measured prove that the thickness of the envelopes and the cores are in direct proportion to the cooling ratios C/M.

In Fig. 17 (*d*) the section of the cast-iron mould in which ingot *d* was cast reveals the influence of the cooling surfaces of the sand mould in which the ingot mould was cast. The weak chilling action of the internal corners and the vigorous chilling action of the external corners is well shown. The effect of the crystallisation in fine radial crystals at the corners and sides, typified by the close grain formation, the coarsely graphitic zone where cooling was slowest, and the spongy areas near the internal corners of the mould quenching steels; that when a billet and a thin wire of the same material are quenched in water from above the Ac1 point, the wire may be glass hard whilst the billet is still soft.

The rapidity of freezing as influencing the chill envelope in low silicon cast-iron is shown in Fig. 19, where (*a*) is the case of the metal poured through water into a very thin water-cooled mould, (*b*) that of a thin water-cooled mould, (*c*) that of a thick metal mould, and (*d*) that of a warm sand mould. The four cases present a series of diminishing rates of freezing and cooling.

In (*a*) the decomposition of the iron carbide is almost entirely prevented if the mould is small enough, and even in the case of iron containing 1¼ per cent. silicon small thin castings in thin water-cooled moulds are practically graphite free, the primary crystallites being austenitic (see Fig. 20 below). In this connection the influence of such rapid cooling is shown in the cooling curves of a 1¼ per cent. silicon cast-iron of 3·5 per cent. total carbon, 4 per cent. manganese, and low sulphur and phosphorus. The curve A, Fig. 20*a*, illustrates a cooling effected in 3 minutes, whereas B was that of a cooling effected in 1 min.

Fig. 17. FRACTURES OF SMALL CAST INGOTS IN MOULDS OF VARYING THICKNESSES

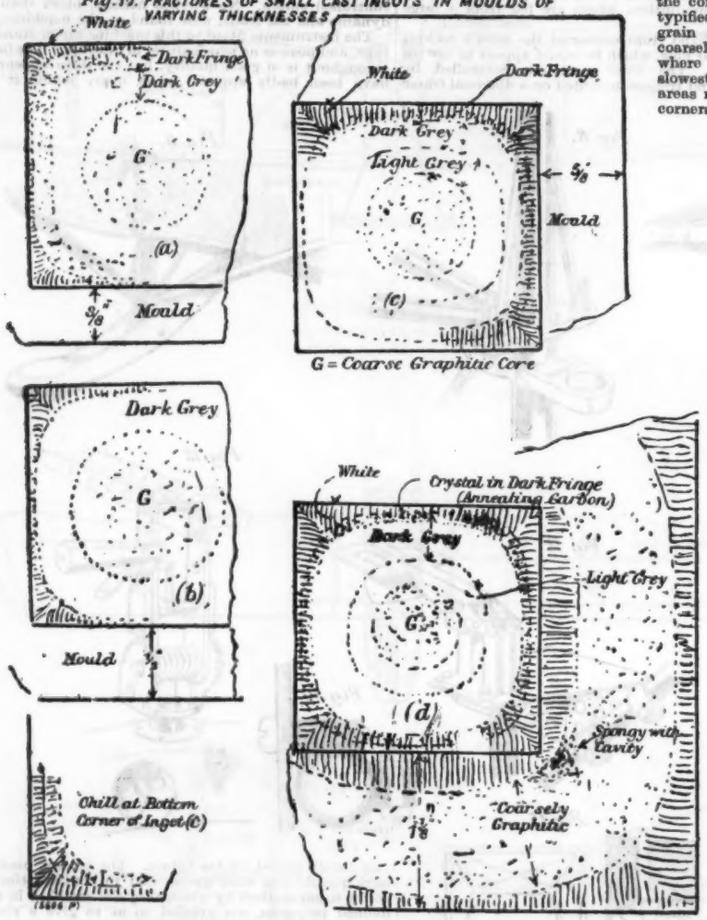


Fig. 18.

Fig. 19. INFLUENCE OF RATE OF COOLING

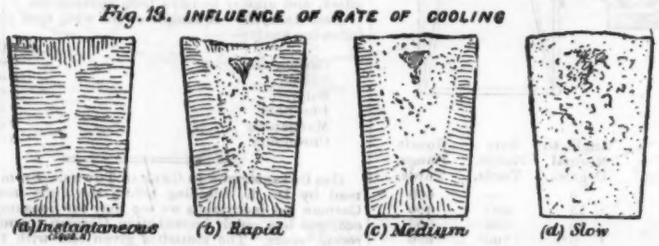


Fig. 20.

13 in. outside diameter, the thickness of the congealing envelope was measured every minute and the results plotted. The volume of the metal frozen progressively was found to be closely proportional to the value of the ratio C/M, where C = cooling surface at outside of each ring and M the volume of the metal frozen in each minute interval.

Grey cast-iron ingots, cast in moulds of varying thickness, when fractured give an excellent index to the rate of freezing as influenced by mass of mould. If the iron is low in carbon (hypo-eutectic) the fracture characteristics give clearly defined differences of structure, due to the rate of cooling from the molten, and these, when further examined microscopically, are most instructive.

A series of small ingots 1¼ in. square were cast in moulds of mass 1, 1½, 2 and 4 times that of the ingot. Fig. 17, *a*, *b*, *c* and *d*, gives the fractures reproduced carefully by hand, photographs not yielding with showing that the masses last to freeze and towards which the occluded gases flow, are in such cases quite near to the mould surface. The sand core of the mould acted as a non-conductor of heat, the hot corners of which, in assisting to keep liquid the metal adjacent thereto, promoted the formation of "pipe" in the area close to the hot internal corners.

Many test ingots of similar character, made for the purpose of testing the depth of chill for rolls and other chill castings, have been carefully studied, and these also have yielded interesting information on the subject of crystalline structure as related to the rate of cooling as influenced by mass of mould and ingot and of temperature of casting.

Generally, it is very evident that the steepness of the outer skin temperature gradient is the index to the chill thickness, and also that of the carbon retained by chilling in the combined state. The steeper the skin zone temperature gradient, the greater is the volume of the carbide within that skin zone. This is but another illustration of Dr. Stead's statement that temperature gradients are a measure of the hardening effect when

The rapidity of cooling in B has suppressed the heat evolution at the point of freezing of the primary austenitic crystals which in slower cooling become troostitic, or possibly of partially decomposed pearlite containing fine graphite. The period of eutectic freezing is shortened and the separation of graphite within this narrow temperature zone is hindered. This again affects the Ar1 range, the quick cooling diminishing the extent of the recalescence.

The suppression of dilatation by rapid cooling has long been known to investigators of permanent mould processes in iron foundries. The troubles which were feared during the freezing range when dilatation was expected did not occur, the sudden chilling having suppressed the heat evolution and dilatation. The graphitic separation at the pearlite point and the accompanying expansion were also reduced. The introduction of pressure on the liquid until complete freezing takes place, as in the Harmet process, would also appear to suppress the recalescence phenomenon, the heavy moulds and quick freezing no doubt assisting in such suppression. Here the influence of pressure during

* Paper read before the Iron and Steel Institute, on Friday, September 13, 1918.

freezing on steels having varying percentages of those elements or alloys which foster quick freezing, such as chromium-nickel carbon and manganese in comparison with those which tend to retain the metal in the liquid or quasi-liquid state; silicon, for example, is of great importance. Such research is only possible by means of a series of pressure curves of the type used by Mr. Harmet.

There is little doubt that when molten steel is poured into an ingot mould with thick walls the envelope freezes rapidly, the temperature gradient being steep. It might be expected that with steels of higher carbon percentage than, say, 0·5 per cent., the outer skin of the ingot would be hard when the initial temperature head is in the region of 1,450 deg. to 1,500 deg. C. But, as already shown, the steepness of the gradient rapidly decreases as the axis is approached. This steepness is the cooling velocity index, which, being expressed in degrees of fall per inch of radius per second determines the magnitude of the retention of carbon in solution. It has been seen that the heat absorbed by the mould is greatest during the first few seconds after casting. The chilling action of the mould must be sufficient to cause the outer zone of the ingot envelope to fall below the Ar1 point, or hardening of course cannot occur. Even though incipient hardening of the skin zone may momentarily take place through a certain thickness, this hardening will be annealed off unless the mean temperature of the ingot falls rapidly to below the Ac point. This action is perhaps best illustrated by reference to the quenching of steel of, say, 0·5 per cent. carbon at, say, 900 deg. C., by a quick dip into cold water followed as quickly by withdrawal and air cooling. If such a stout bar of steel be treated in this way the outer skin when withdrawn may be at, say, 500 deg. C., skin-hardening having taken place. Soon, however, the internal heat remaining in the centre of the bar, which has possibly only fallen to 800 deg. C., will pass outwards, heating or annealing the outer hardened envelope, whose temperature may then reach 700 deg. to 750 deg. C.

Suppose the first brisk quenching hardens one-tenth of the volume of the bar, lowering its temperature to 600 deg. C. On withdrawal the internal nine-tenths of the bar may be at 800 deg. C. The common temperature reached more or less quickly by the annealing effect is 780 deg. C.

If allowed to cool slowly in the air the outer chill will disappear. If, however, the quenching is drastic enough to harden half the volume of the bar, the temperature falling to, say, 500 deg. C. and the centre of bar to 750 deg. C., it is readily seen that after the withdrawal the common temperature cannot exceed 625 deg. C. The bar remains hard.

Similarly, in the chilling of an ingot the initial temperature head may be sufficient to produce a steep temperature gradient across the outer envelope, and if the carbon content is high enough there will be at first a hardening effect within this skin zone. The internal mass, however, remains at but little below the freezing temperature, whilst the outer envelope has perhaps fallen to 600 deg. C. But coincidently the mould surface is rising in temperature and the temperature head is thereby reduced, and with it the temperature gradient slows down. The outer envelope of the ingot may fall, say, 900 deg. C., whilst the corresponding contact zone of the mould rises by, say, 400 deg. C. The temperature head has thus fallen from 1,500 deg. to 200 deg. C. in the contact zones. At the same moment the inner mass of the ingot may be at, say, 1,400 deg. C. The head now operating from the inner mass to the outer chilled envelope is 1,400 deg. — 600 deg. = 800 deg. C. Hence the skin becomes softened by annealing from within.

It must not be forgotten that the outer skin is always lower in carbon than the interior of the ingot, by reason of the fact that the earliest crystallites frozen there must be lower in carbon than the mother liquor last to solidify; the lower temperature of whose solidification is a proof that the carbon content therein is below that of the mean. This general softening effect prevents what might otherwise be a constant source of trouble in ingot work. In certain alloy steels the trouble is always present, and rapid freezing is therefore not so advantageous as in the case of milder carbon steels.

The function of internal heat annealing of the outer envelope of ingots must have a considerably important value in determining the structure in the cold of the entire ingot mass. The final structure must be influenced by the rate of chilling, and though many tests have proved that rapidly-chilled compressed steel give superior results to slow-cooled uncompressed steel cast from the same "heat," it does not yet seem to be proved that the extra cost of compression of the freezing ingot is worth incurring, unless it be in the sense of eliminating pipe by some simple and efficient plant, such as that recently devised by Mr. Talbot. On the other hand, there is the manifest disadvantage of creating a very coarse crystalline interior in the case of large ingots with hot feeder-heads, even though that structure be free from "piping" and its incidental troubles.

In a heavy iron casting the coarsely graphitic interior is often so weak as to yield tensile and other tests indicative of little or no strength. A final reference to cast-iron in the way of illustrating quantitatively the interior back annealing action may be of interest.

In a series of test ingots of No. 5 iron containing 1 per cent. silicon, 0·5 per cent. manganese, 0·4 per cent. phosphorus, and 3·2 per cent. total carbon, the outer zone as per fracture showed a chill envelope 0·5 in. thick, the outer portion of which, 0·3 in. thick, was perfectly white (slightly hypo-eutectic). The inner 0·2 in. of the chill was partly masked by a fringe of finely-divided graphite (amorphous), the chill crystallites being discernible after brushing the fracture.

It is evident that initially the temperature head (about 1,130 deg. C.) was sufficient to bring about a chill zone at least 0·5 in. in thickness. But as the chill mould became hotter the temperature gradient slowed down and the internal heat within the central mass annealed the inner portion of the chill envelope, bringing its temperature up to at least 700 deg. C. This caused a decomposition of the carbide in the inner part of the chill zone with separation of the fine graphite. This annealing action would persist until the temperature gradient at the mould face became steeper than that at the junction of the inner surface of the chill envelope and that of the inner and hotter mass.

The action can be outlined quantitatively thus:—

4-In. Ingot. Mould three times Weight of Ingot.

Temperature of molten iron = 1,150 deg. C.
Temperature of initially frozen ingot skin 0·5 in. thick = 500 deg. C.
Volume of envelope 0·5 in. thick, 12·56 — 7·06 = 5·5 deg. cubic inches.
Volume of internal hot mass = 7·06 deg. cubic inches.

Mean temperature of ingot when 0·5 in. chill has fallen to 800 deg. C. and inner mass to 950 deg. C.:—

$$\frac{5\cdot5 \times 500 \text{ deg.} = 2{,}750 \quad 7\cdot06 \times 950 \text{ deg.} = 6{,}700 \quad 9{,}450}{12\cdot56 \qquad 9{,}450 \qquad 12\cdot56} = 760 \text{ deg. C.}$$

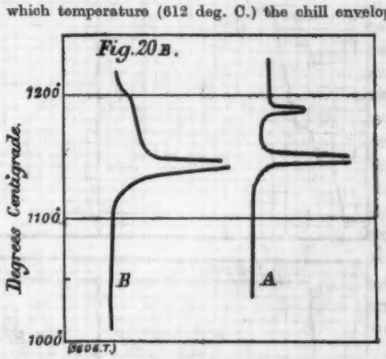
At this temperature part of chill is annealed and carbide decomposed. Later:—

Chill temperature falls to 400 deg. C.
Thickness of chill envelope is reduced to 0·3 in.
Inner hot zone has fallen to 700 deg. C.
Volume of chill envelope is now 12·56 — 9·06 = 3·5 cub. in.
Volume of hot inner zone = 9·06 cub. in.

Mean temperature of ingot has now fallen to 400 deg. C. Hence mean temperature of ingot falls to:—

$$\frac{3\cdot5 \times 400 = 1{,}400 \quad 9\cdot06 \times 700 = 6{,}300 \quad 7{,}700}{12\cdot56 \qquad 7{,}700 \qquad 12\cdot56} = 602 \text{ deg. C.}$$

At which temperature (612 deg. C.) the chill envelope



is permanent, further cooling having no effect on the decomposition of carbide (Fe_3C).

This method of analysis of the action of cooling, relating temperature head with the temperature gradients, the ratio of ingot to mould mass, and the influence of these with the time factor on the ingot structure, zone by zone from the outside to the axis, is capable of yielding most valuable data of a highly practical nature. The author has only attempted to outline the steps whereby more systematic research would enable further progress to be made in our knowledge of the influence of mass on slowly and quickly-cooled or heated cast-iron and steel.

He wishes particularly to acknowledge his indebtedness to the work of Messrs. Stead, Arnold, Howe, Hatfield, McCance, Deach, Edwards, Carpenter, Law, and Le Chatelier on the more purely scientific side, and of Sir Robert Hadfield and Messrs. Harmet, Talbot Brearley and Kilby on the side of works practice, in enabling the subject at issue to be approached.

A long experience in touch with the manufacturing and user's phases has given opportunities for continuous observation of the phenomena of heating and cooling of metals. Though the paper has mainly dealt with the cooling of metal masses, the principles involved are, in the reverse sense, related to the heating of such materials and have a distinct bearing on problems of furnace design and heat treatment.

It should perhaps be mentioned that the greater portion of the paper has been lying aside for ten years or more, but in view of the increasing interest arising of late in the subject-matter of ingots and of cooling phenomena, it was thought that possibly some of the details of the author's work might supplement that of other and more capable investigators, whose research apparatus is of greater accuracy than that available to the author.

A NEW THEORY OF THE STEAM TURBINE: ERRATUM.—On page 245 *ante*, column 3, near middle, read $\frac{e_1}{R_1}$ for $e_1 R_1$, and $\frac{e_2}{R_2}$ for $e_2 R_2$. Also on the same page, line 3, from the reference made to Mr. H. L. Guy, should have been to Circular No. 1435/2A, issued by the British Westinghouse Company, Limited.

GERMAN WAR PROFITS.

The German iron, steel and mining industry continues to declare very substantial dividends, although the climax may perhaps have been passed.

The Bochum Union, which in the course of the present year has increased its capital from 36,000,000 marks to 45,000,000 marks, has not been quite able to keep up the dividend of 25 per cent. of the two previous years, and has seen fit to reduce it to 22½ per cent.; this, however, is considerably above the highest pre-war dividend, which during the company's 60 years of existence never exceeded 16½ per cent. The gross profits, about 23,000,000 marks, were about the same as for the two preceding years, though slightly exceeding the latter figures, and writings-off amounted to 7,400,000 marks against 5,330,000 marks for the previous year, during which, however, 2,000,000 marks had been reserved for reconstruction, which item does not figure in the last balance sheet.

The Kattowitz Mining Company shows gross profits for last financial year of 10,837,657 marks against 9,950,922 marks for the previous year, writings-off again amounted to 2,500,000 marks and the surplus amounted to 7,300,665 marks against 6,591,431 marks. The dividend was again fixed at 12 per cent. The share capital for the year was 39,000,000 marks. The coal production has somewhat increased, whilst the output of the iron works is practically stationary. The company, in the course of the last year, has acquired 983 "portions" of the German Graf Renard concern, which were formerly held by French owners, and for which the purchase sum amounted to 17,694,000 marks, for which the money had partly been borrowed. It has been decided to increase the share capital from 39,000,000 marks to 52,000,000 marks.

The Hoesch Iron and Steel Works have again done exceedingly well during last year, the gross profits amounting to 27,630,549 marks against 27,586,018 marks for the previous year, the net profits for the two years being respectively 18,066,952 marks and 17,529,294 marks; 2,000,000 marks were reserved for repair of works, and 3,500,000 marks for losses on ore delivery contracts, for which purposes nothing was set aside in the previous year. The dividend was again fixed at 24 per cent. In addition it was decided to give the shareholders the benefit of the dividend regulating fund, accumulated during past years up to 1913, which in the previous balance sheet figured at 4,000,000 marks. The capital of the company has been increased by 12,000,000 marks, and the new capital is entitled to dividends for the current year.

The Hohenlohe company pays a dividend for last year of 8 per cent. against 6 per cent. for the preceding year; the writings-off amounted to 9,510,164 marks against 7,357,862 marks for the preceding year. The report states that the contract with the State mining department, concerning "portions" of the deposits "Eustachius" and "Bronislawa" expired on August 1, 1917, and, as the other side had not fully carried out the agreement, a compensation was due to the company, the amount of which was to be fixed by arbitration; in the meantime 2,504,861 marks had been paid in, which, less the 270,684 marks at which these deposits stood booked, had been added to the gross profits, but again transferred to some special writings-off, as the rental of 200,000 marks per year would now cease. The work on the Oehringen deposits had been proceeded with. The coalfields now being worked, stand booked at 57,900,000 marks.

The Rhenish Steel Works, Duisburg and Meiderich have again had a very satisfactory year, and the gross profits for 1917-18 amounting to 25,069,811 marks and the net profits to 9,069,811 marks, against respectively 23,551,493 marks and 8,146,112 marks for the preceding year. A dividend of 12½ per cent., the same as last year, has been declared. A sum of 10,000,000 marks was added to the depreciation fund, against 9,000,000 marks the previous year, the increase being due to heavier calls upon the plant. A special reserve, principally for war taxation, was endowed with 6,000,000 marks, the same as the previous year. The share capital is now 60,000,000 marks, which receives the full dividend, whilst last year 12,000,000 marks war shares only received 5 per cent. The company's gross profits for last year were 2½ times those of 1913-14 and between three and four times those of 1914-15.

NEW TYPE OF WATER TURBINE.—Starting from the consideration that there is a gap between the Poncelet water wheel and the Francis turbine, Donát Bánki has experimented with a somewhat novel style of turbine of simple construction, which may be described as a water wheel with internal flow. The wheel has a horizontal shaft and is provided with buckets all round; the water enters the buckets through guide vanes on the one side about 90 deg. from the vertical axis of the wheel, flows through the hollow interior of the wheel, and passes into the buckets on the other side from which it is then discharged. With proper adjustment of the vanes and curvature of the blades the movement of the water through the buckets on both sides, entering and leaving, and through the wheels should take place in regular stream lines without shock, and a high efficiency should be realised. In experiments and brake tests made with a wheel, 1 m. long, 0·5 m. diameter (*Zeitschrift Verein. Deutsch. Ingenieure*, August 3, 1918) Bánki obtained a hydraulic efficiency of 89 per cent., which he further raised to 92 per cent.; the formula which he gives is his formula for calculations of the hydraulic efficiency of steam turbines with symmetrical blades. Simplicity of construction, especially of the bearings, is the chief advantage claimed for the turbine.

CATALOGUES.

Hand Machines.—Messrs. Wagner and Co., St. Etienne, Loire, France, send a sumptuously produced catalogue of their portable drilling and grinding machines with electric drive. In addition to simple forms for easy open work there are many special forms for awkward places and special purposes. There are also convenient well-designed fittings for converting the machines to temporary bench use and occasional lathe use; the latter by bolting in the ordinary tool clamps or by substituting a special slide rest. All the large makers of these machines show a most willing and ingenious disposition to meet the practical difficulties of the workmen, and Messrs. Wagner and Co. are behind none in this respect. Such a catalogue should, however, be available in English, more especially at the present time.

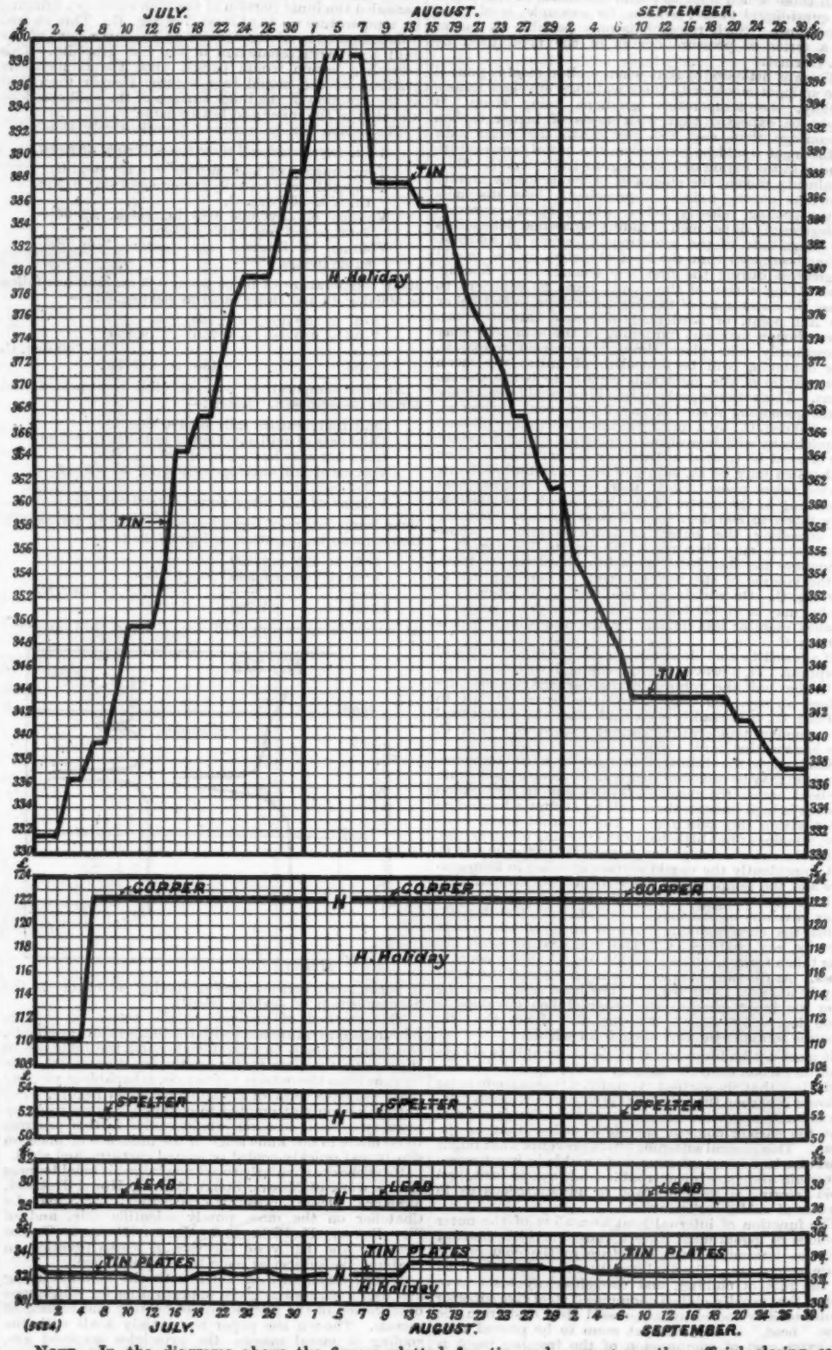
Coke Oven Machinery.—In the United States the coking industry is being developed on the giant scale which is so characteristic of that country. No beehive ovens have been built for some years, having been superseded by such types as the Mitchell oven, which is adapted to machine stoking and is also a non-recovery oven. By-product ovens in the United States have increased in number from 4,624 in 1911 to 7,660 in 1917, and it is estimated that over 12,000 will be in operation at the end of next year. A catalogue from the Wellman-Seaver-Morgan Company, Cleveland, U.S.A., shows the stoking machinery used on the large scale. The ovens are charged with coal by a hopper lorry car running on top of the oven structures; it is then levelled by mechanical rams; after coking, the doors are removed by another machine and the coke pushed out by another. The ovens are built in single or double rows and the levelling and discharging machines travel along on rails of 28 ft. span working the series. Koppers and Semet-Solvay ovens are chiefly shown. In one case a door-lifting machine is suspended from overhead rails. Figures of capacity in tons per day are not given, unfortunately, but it is evident that the company has made a special study of this plant and worked it out on efficient lines. No doubt the Americans will help to put the French coke industry on its feet again. The French demand, supplied by Germany before the war, was 4,000,000 tons of coke per year.

The German Potash Industry.—The German Potash (Kali) Syndicate has forwarded a report to the Legislature, in which a somewhat pessimistic view is taken of the future of this important industry, which perhaps, is one of those branches of the trade which has caused the most disappointment in Germany. The report states that a great deal is being said and written about the world monopoly of the German potash industry and of the inferior harvest in hostile countries due to the shortage of mineral manures. This has given rise to the belief that the German potash industry will earn vast sums directly the war is at an end. The industry itself is quite aware of there not being any deposits of material importance in other countries; but contrary to what may be the current idea, the experts are of opinion that all conditions for an export trade of any great magnitude are wanting, namely, a sufficient number of adequate installations at the mines, with adequate labour, coal and stocks. In consequence the German potash industry will not by a long way be able to satisfy the anticipated demand from abroad during the first few years after conclusion of peace, even if the requisite tonnage were available, which may be very questionable. Consequently any large profits cannot be reckoned upon immediately after the cessation of hostilities, and should such profits materialise later on a large portion of them will be required for bringing the works up to the required capacity.

Artesian Well Fields in Queensland.—In the inland districts of Queensland it is generally necessary to sink artesian wells to secure water for stock, and there were in service up to the beginning of 1918 considerably more than 3,000 artesian wells in the State. These have an average depth of 1,000 ft. The one supposed to be the deepest is at Springleigh, in the Blackall district of Central Queensland, and has a depth of 5,700 ft. A well located on the Manfred Downs is only 10 ft. deep and has a flow of 2,000 gallons a day. There are about 1,200 flowing wells in the State; the total amount of water from them is estimated at 430,342,000 gallons daily. The total cost of the wells has been estimated at 625,000*l.* The following are the charges for boring only, in sinking an artesian well: For the first 1,000 ft. 16*s.* per foot; 1,000 ft. to 2,000 ft., 17*s.* 6*d.*; 1,500 ft. to 2,000 ft., 18*s.* 6*d.*; 2,000 ft. to 2,500 ft., 19*s.* 6*d.*; 2,500 ft. to 3,000 ft., 20*s.* 6*d.* These prices, of course, depend largely upon means which can be secured for the sinking and transportation facilities for the material. For the average-sized farm which does not have an artesian well, water may be secured from some adjoining property on which there is a well. The usual charge is about 50*l.* per annum. Government assistance is given to farmers and pastoralists in putting down artesian wells. As an example of the extent of this assistance, the following estimates are given: For sinking a well on a grazing area of 60,000 acres, 1,950*l.*; and 20 miles of drains, at 15*l.* per mile, 300*l.*; the whole amount being advanced by the Government and considered as a loan for a term not exceeding thirty years. The annual expense to the farmer on account of the loan is calculated at the rate of 6*l.* per 100*l.* interest and redemption per annum. For maintenance approximately 200*l.* is required, making a total charge of about 325*l.* per annum. At the end of the period the well becomes the property of the farmer.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

Spanish Year Book of Mining, Metallurgy and Industry.—The "Anuario de Mineria Metalurgia, Electricidad y demas Industrias de España, for 1918, published by the *Revista Minera*, Madrid, has now appeared. It gives the capital, the names of the members of the board, the mines and works, of all the various mining and industrial companies located in Spain; also a directory of the various industrial companies having representatives in the country, the address of the representatives; the names of the different Spanish mining and industrial authorities. The names of several British and foreign members of a number of companies' boards need revision. Apart from that, the book is a useful guide for foreign firms having business connections with Spain, or desirous of entering the trade with that country.